GEOGRAPHY,
RESOURCES & INDUSTRIES

August, 1944

AUG 1944

EDISON ELECTRIC INSTITUTE BULLETIN

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PUBLISHED MONTHLY BY EDISON ELECTRIC INSTITUTE

THE ELECTRIC LIGHT AND POWER INDUSTRY

Current Statistical Data Covering 100 Per Cent of Industry

May, 1943 and 1944

SOURCE AND DISPOSAL OF ENERGY—MONTH OF MAY

	1944	1943	%
GENERATION* (Net)			
By Fuel Burning Plants	11,801,533,000	10,664,765,000	+10.7
By Water Power Plants	7,262,862,000	7,191,704,000	+ 1.0
Total Generation	**19,064,395,000**	**17,856,469,000**	**+ 6.8**
Add—Net Imports over International Boundaries	153,308,000	150,742,000	+ 1.7
Less—Company Use	139,200,000	136,233,000	+ 2.2
Less—Energy Used by Producer	461,290,000	786,825,000	−41.4
Net Energy for Distribution	**18,617,213,000**	**17,084,153,000**	**+ 9.0**
Losses and Unaccounted for	2,384,947,000	2,338,841,000	+ 2.0
Sales to Ultimate Customers	**16,232,266,000**	**14,745,312,000**	**+10.1**

CLASSIFICATION OF SALES

NUMBER OF CUSTOMERS—As of May 31st			
Residential or Domestic	27,069,158	26,709,647	+ 1.3
Rural (Distinct Rural Rates)	1,126,949	1,071,752	.....
Commercial or Industrial:			
Small Light and Power	4,200,329	4,161,368	+ 1.0
Large Light and Power	149,002	145,047	
Other Customers	118,365	118,993	.....
Total Ultimate Customers	**32,663,803**	**32,206,807**	**+ 1.4**
KILOWATTHOUR SALES—During Month of May			
Residential or Domestic	2,471,883,000	2,241,041,000	+10.3
Rural (Distinct Rural Rates)	269,223,000	218,859,000	+23.0
Commercial or Industrial:			
Small Light and Power	2,348,661,000	2,229,331,000	+ 5.4
Large Light and Power	9,521,704,000	8,520,401,000	+11.8
Street and Highway Lighting	154,890,000	148,176,000	+ 4.5
Other Public Authorities	800,399,000	731,775,600	+ 9.4
Railways and Railroads:			
Street and Interurban Railways	365,111,000	370,603,000	− 1.5
Electrified Steam Railroads	217,449,000	206,230,000	+ 5.4
Interdepartmental	82,946,000	78,896,000	+ 5.1
Total to Ultimate Customers	**16,232,266,000**	**14,745,312,000**	**+10.1**
Revenue from Ultimate Customers	**$267,136,000**	**$245,874,700**	**+ 8.6**

RESIDENTIAL OR DOMESTIC SERVICE

AVERAGE CUSTOMER DATA—For 12 months ended May 31st			
Kilowatthours per Customer	1,112	1,038	+ 7.1
Average Annual Bill	$39.59	$37.89	+ 4.5
Revenue per Kilowatthour	3.56¢	3.65¢	− 2.5

(*) By courtesy of the Federal Power Commission.

Vol. 12, No. 8, EDISON ELECTRIC INSTITUTE BULLETIN; published monthly. Entered as second-class matter Aug. 17, 1933, at the post office at Philadelphia, Pa., under the act of March 3, 1879. Publication office, 56th and Chestnut Sts., Philadelphia, Pa. Editorial office, 420 Lexington Ave., New York, N. Y. Subscription rate $2.00 per year in the United States; $3.00 per year in foreign countries.

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EDISON ELECTRIC INSTITUTE BULLETIN

Volume 12 AUGUST, 1944 No. 8

Planning for Economies Yet To Be Had in System Costs

By S. M. Dean

Chief Engineer of the System, The Detroit Edison Company

Address before the Annual Meeting of the Edison Electric Institute, New York, June 7, 1944

WE often hear it said of the electric utility business that all the major engineering problems have been solved and that only refinements remain. To some degree that is true. In the early days of our business our problems were predominantly those of developing the tools to keep ahead of the rapidly rising demand for electric service. "Anything, Oh! Lord, to keep ahead of the load."

Today, the tools and methods to deal with the load are very largely available. It is no longer a question of whether we can produce the physical equipment to meet the demand, but rather how to do it at a lower cost in the face of the rising cost of the component parts which we must use. It is to this latter field of application engineering that we must now direct our attention.

We are no longer a monopoly. We are faced with competition by government agencies whose costs of doing business are ostensibly lower than those of the private utilities. Also, following the war we shall surely be faced with higher taxes than we had before the war. On the basis of earlier designs, our equipment costs would be higher, and in any case the cost of labor will be higher than we have known in pre-war days.

To proceed on the basis of orthodox methods and practices, in the face of such a situation, would be most unwise.

It seems to me that we would do well to profit by the practices of manufacturing companies that regularly do business in highly competitive markets. They first determine the type and quality of product they must have to satisfy the customer, and they next set the price at which they think they can sell it in competition. This bogey is then turned over to the designer and the producer. These latter often squirm under the pressure, but, when the problem is defined, they somehow find a way to meet it. That is the mechanism of progress.

Using that approach, we must first re-examine the actual needs of our business, and we shall then be in position to use our wits to accomplish that result with the minimum cost in equipment and personnel.

So much for the frame of mind in which we should approach our new problems. A proper frame of mind is, in my opinion, the single most important consideration. With a will to do and an understanding of the requirements, the battle is often half won.

The Requirements

In general, an electrical system is designed to provide the required amount of power within the allowable range of voltage and with a suitable degree of reliability of service. I shall not deal to any extent with the matter of voltage since it can be measured with an instrument which will indicate at once whether it is within the allowable range. The determination of what constitutes adequate reliability is much more difficult, and it is to that requirement that this paper is principally directed.

We are all cognizant of the increasing dependence of our customers on our service. Lighting, heating by oil burners and stokers, cooking, waterheating, refrigeration, and a multitude of other services will not often brook long outages. On the other hand, an examination of the operating record of a system shows surprisingly good service continuity.

Consider Figure I: It shows the number of interruptions per year experienced by the average customer in the several areas of our system. The interruptions are classified by causes, and the average duration from each of the several causes is shown. Short interruptions, where service is restored in a minute or two by the reclosing of a circuit breaker, are not included.

Class A shows the interruption record for a large city having multiple underground transmission lines and mainly overhead distribution lines. On the average, there is only one interruption of consequence in four and one-half years from all causes, including the customer's own equipment. The average duration of outage is only 58 minutes, which means that we give service 99.997 per cent of the time. Also note that about half the outages are caused by the customer's own equipment, which means that there is only one outage in nine years to the average customer chargeable to the power company.

It is recognized that the customer is likely to forget the many hours of good service when an outage occurs. On the other hand, it behooves us to give consideration to the very large number of hours in which our service is on. That represents the quality of service that can be rendered to metropolitan customers when served almost entirely by overhead distribution lines; that is, without resort to duplication of lines.

It has been suggested that the a-c network, with its duplication of primary feeds, complicated transformers and switching equipment, and subsequent higher costs, be extended to these residential and commercial areas. Clearly such complication and cost are not warranted when service of the quality here shown can be given without it. The above result has been accomplished by

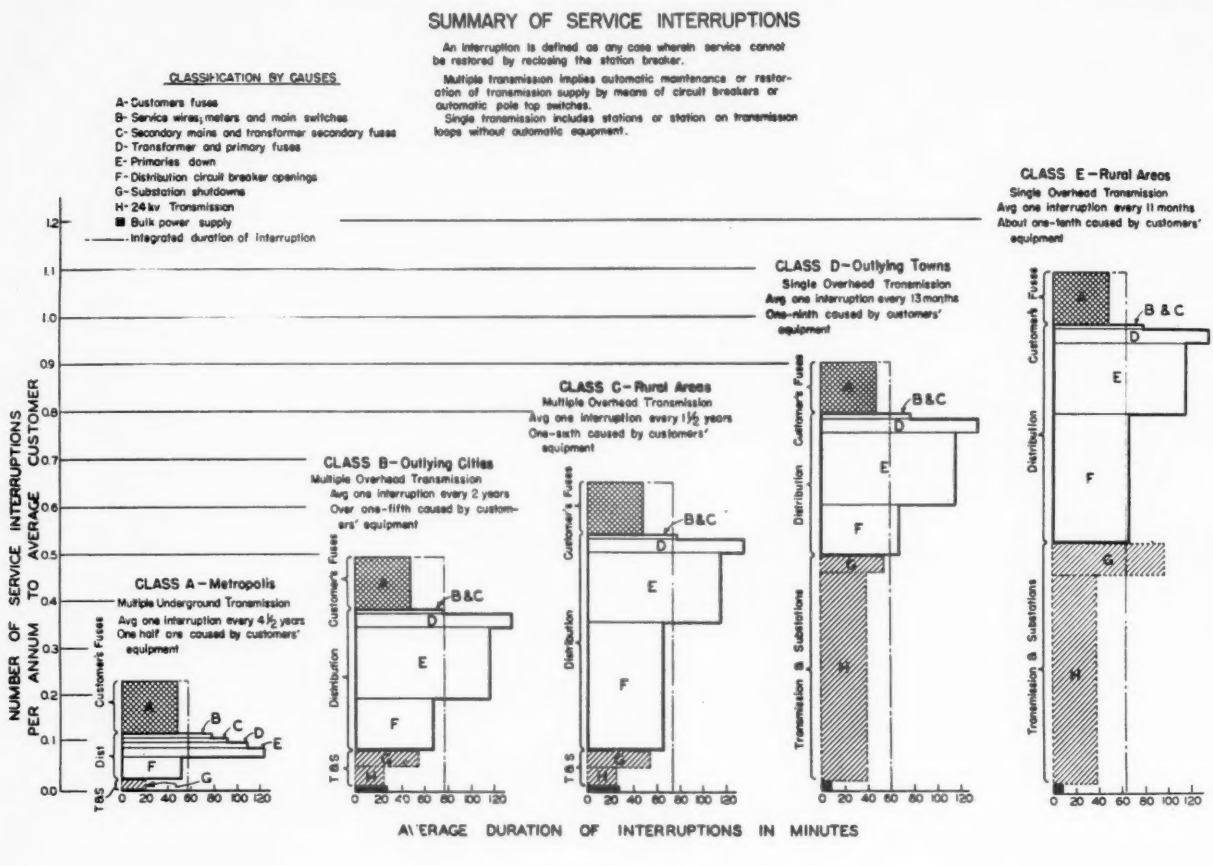

SUMMARY OF SERVICE INTERRUPTIONS
An interruption is defined as any case wherein service cannot be restored by reclosing the station breaker.
Multiple transmission implies automatic maintenance or restoration of transmission supply by means of circuit breakers or automatic pole top switches.
Single transmission includes stations or station on transmission loops without automatic equipment.
CLASSIFICATION BY CAUSES
A- Customers fuses
B- Service wires, meters and main switches
C- Secondary mains and transformer secondary fuses
D- Transformer and primary fuses
E- Primaries down
F- Distribution circuit breaker openings
G- Substation shutdowns
H- 24 kv Transmission
Bulk power supply
Integrated duration of interruption
CLASS A – Metropolis
Multiple Underground Transmission
Avg one interruption every 4½ years
One half are caused by customers' equipment
CLASS B – Outlying Cities
Multiple Overhead Transmission
Avg one interruption every 2 years
Over one-fifth caused by customers' equipment
CLASS C – Rural Areas
Multiple Overhead Transmission
Avg one interruption every 1½ years
One-sixth caused by customers' equipment
CLASS D – Outlying Towns
Single Overhead Transmission
Avg one interruption every 13 months
One-ninth caused by customers' equipment
CLASS E – Rural Areas
Single Overhead Transmission
Avg one interruption every 11 months
About one-tenth caused by customers' equipment
NUMBER OF SERVICE INTERRUPTIONS PER ANNUM TO AVERAGE CUSTOMER
AVERAGE DURATION OF INTERRUPTIONS IN MINUTES
Customer's Fuses
Distribution
Transmission & Substations
T&S
Dist
B&C

Fig. 1

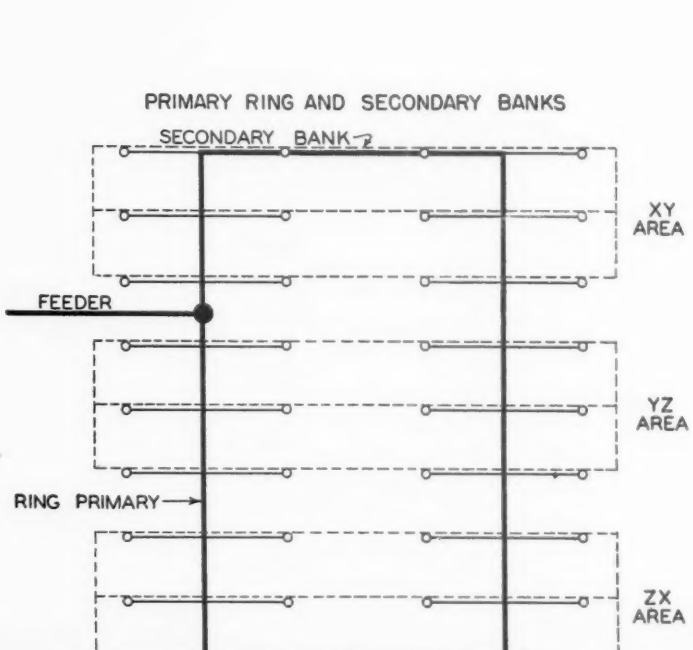


Fig. 2

making use of ringed primary lines and by operation of distribution transformers in parallel on secondary mains that are also closed into rings. We call these arrangements "primary rings" and "secondary banks."

Figure 2 shows such an arrangement of lines. The heavy solid line represents the main primary ring with the feeder coming in from the left. Note that off this primary ring in either direction are primary laterals represented by the lighter solid lines. These feed the distribution transformers shown as small circles. The dashed lines represent the secondary mains which it will be noted are also closed into rings.

Usually, if the primary ring burns in two or breaks for any other reason, no service is interrupted. Should a primary lateral serving distribution transformers burn off, those transformers will be out of service, but the secondary ring mains will hold that load until the defective primary can be repaired. Experience has shown that, where the secondary ring mains are fed by six or more transformers totaling 100 kva or more, secondary

troubles will almost always burn clear. As Class A of Figure 1 indicates, the character of service resulting from this arrangement of lines is almost unbelievably good.

Consider Class B in Figure 1: It illustrates the service continuity in the larger outlying cities served by several overhead transmission lines, sectionalized by local switching equipment, but in which cities the use of primary rings and secondary banks on the distribution lines cannot usually be resorted to.

Note that, considering all causes, there is an interruption to the average customer about every two years; and, considering only causes chargeable to the power company, once in two and one-half years. The average duration is about 80 minutes, which means that we give service here about 99.994 per cent of the time.

Class C illustrates the performance in the rural areas served by several overhead transmission lines sectionalized by local switching; Class D, outlying towns served by a single "through" overhead transmission line, that is, one fed from both ends; and Class E, rural areas also served by a single "through" overhead transmission line.

Comparatively, the service in these latter classes is less good than in the preceding ones. But, even in the least good case—Class E—our service is on 99.987 per cent of the time. Also, it should be borne in mind that relatively few customers are involved in these latter classes and that it is not so long back that many of them were still using oil lamps and gasoline engines. Our least good service is so far ahead of oil lamps and gasoline engines that, by comparison, it is highly desirable.

When considering improved reliability of service, we would do well to ask ourselves, as customers, to what extent we would be willing to have our electric bills increased to improve the reliability of the service. It seems very doubtful if the average customer would be willing to accept any increase in his electric bill for that purpose.

There is another aspect of this chart which is revealing; that is, that the causes of interruption fall naturally into three classes. They are as follows:

1. Those interruptions caused by the customers' own equipment and therefore not related to the customers' location;

2. Those interruptions caused by failures of distribution lines. These, as would be expected are the most troublesome, both as to frequency of occurrence and duration. They are represented in the several classes of Figure 1 by Items B, C, D, E and F. Distribution outages are, of course, a greater factor on rural lines as is indicated in Classes C and E; and

3. Those interruptions caused by transmission lines and substations (Items G and H in the several classes of Figure 1). These are most frequent in the outlying areas covered by Classes D and E in Figure 1, because these substations are tapped directly off the transmission lines without the benefit of local transmission switchgear.

Failures of bulk power supply are rare; but, when they do occur, they affect large numbers of customers—hence, their importance.

A diagram, such as Figure 1, cannot be followed slavishly; but, kept in its proper perspective, it can be very useful. It tells us that the quality of service which is inherent in the type of equipment naturally adaptable to the areas to be served, can, with relatively little added investment, be made to give service plenty good enough on the average. It also indicates in which part of the system lies the most promise of improvement. However, its greatest value is that it gives a factual basis upon which to determine the degree of improvement to be had by a given change, and permits us to weigh that improvement against the cost before going ahead. Of course, there are specific situations in which further improvement is necessary and that is a commercial matter; but the chart tells us that, if we attempt general improvement by the old orthodox methods, we shall most likely be gilding the lily. Altogether, such a chart provides an excellent background against which to view troubles, particularly while we are still smarting from them.

So much for the need and the opportunities for improvement in service reliability.

While the matter of improved voltage is less difficult of appraisal, there is one aspect we should bear in mind, and that is the minimum allowable voltage under emergency conditions. In general, that value is set by the minimum voltage at which appliance motors will start, and is about 100 volts expressed in terms of lamp voltage. Where the emergency voltage can go much below that value, it is necessary to provide additional facilities. It is important, therefore, that any new developments be capable of operating on an emergency voltage down to that value. The present-day fluorescent lamp cannot be depended upon to start much below 110 volts. That matter was discussed with the lamp manufacturers, and they tell us that the new instantaneous-starting type of fluorescent lamp is capable of starting at 100 volts or less. That is an important matter to the designer of systems, and is an excellent illustration of what can be accomplished through cooperation with the manufacturers.

Reduced System Costs

Squarely opposed to the demand for increased reliability is the rising tide of system costs. The cost of everything that enters into the construction and operation of an electrical system is on the upgrade. However, there are some things that we, as engineers and operators, can do about it.

First examine our costs. Of our total cost of doing business, something approaching 60 per cent is proportional to physical plant. Thus, if we can keep down the amount of physical plant required to serve a given load, we shall not only reduce our investment costs, but we shall also realize in time a substantial saving in operating costs. Like the "bazooka," increase in physical plant "shoots both ways," and it behooves us to keep an eye on operating costs when we are planning system expansion.

With the above in mind, what are the directions in which system savings can be made?

Using What We Have

Manifestly, the first step is to make maximum use of what we have. We have been aware, in a general way, of the economic advantage of working equipment harder and accepting a shorter life with attendant higher maintenance. However, it is difficult to determine how rapidly one may be aging equipment by such a process, and there has always been the possibility of badly shortening its life (with the attendant hazard of what the boss might say). The reluctance to take that chance is, therefore, understandable.

However, with the advent of the war it became necessary to really load up our equipment, and to do it on the basis of much higher load factors than we had heretofore experienced. We have had invaluable experience with this higher loading, and that has given us increased operating confidence which should prove of value in the postwar period.

To really appreciate the importance of making maximum use of equipment, it is necessary to bear in mind the small proportion of system investment that is ac-

tually affected by high loading. The following examples will illustrate.

The industry has a large investment in conduit and cable. As used, there is about as much investment in conduit as in cable. The salvage value of the cable will perhaps average 35 per cent of its first cost. Thus, the part of the total investment expendable by loading is only about 65 per cent of the cable itself, or 32 per cent of the conduit and cable investment. Manifestly, we can afford to expend the 32 per cent fairly rapidly to avoid adding cables at 100 per cent investment—provided that in overloading them we do not suddenly reduce their life to something approaching zero by splitting their sheaths from over-expansion due to heating. Solid types of cable would give no warning at the time, and the damage might not be apparent for a year or so.

Experimentation and experience with wartime overloads have increased the loading limits to which we know we can go with reasonable assurance. Also, cables have been developed recently which will give immediate warning of sheath failures, and thereby announce the ceiling of safe loading. With this indication it is much safer to push loadings up into the higher temperature ranges.

The same situation applies to even greater measure to transformers and regulators. The cost of rewinding them is small compared to the total investment involved in transformers, buildings, control accessories and the like; and, again, we can afford to expend the life of the insulation at a fairly high rate rather than install additional units. Fortunately, these devices are much more susceptible of inspection and temperature measurement than is the case with cable, and the hazard in high loading is therefore less. Further, there are new methods of auxiliary cooling for electrical equipment which will greatly enhance its load-carrying ability.

There have also been heavy wartime loadings on generating plants, both as to peak loads and long duration. These have shown what can be done as to outputs, and suggest that if, in addition, plants could be operated at higher short-time loads, more effective use might be made of them for carrying peak loads. The load duration curve shows how very few hours per year it is actually necessary to run at or near peak loads. Also, wartime experience with reduced reserve has shown what can be done in that direction. Again, the proportion of the total investment, subject to rapid wear and tear by higher loading, is small compared to the total investment.

Altogether, our wartime experience with the high loading of electrical equipment and generating plant has shown the hazards to be somewhat less real than we had feared. We should, therefore, be able to continue to take advantage of higher equipment loading after the war.

There still remains the uncertainty as to older equipment, and there is room for experimentation and testing to define its safe loading limits.

Buying New Equipment

Having used our present equipment to its safe limits, we would next have to purchase new.

The manufacturers have also learned some lessons from their wartime experience. They have learned that there are savings to be had from what they call repetitive manufacturing; that is, if ten units of the larger products can be put through on one order, substantial savings can be realized over building them one or two at a time. The theory is that such savings could be shared with the buyer. Accordingly, the manufacturers are urging the users to agree on standardized designs for larger equipment to make such savings possible. This amounts to extending the standardization practice already current in the field of the smaller apparatus into the range of large apparatus.

It might be in order to review our earlier experience with the standardization of smaller equipment. In general, there have been two shortcomings. Too frequently users didn't buy the standard equipment, and there was little pressure from management to do so, particularly if it meant modifications of the user's current practices or involved any incidental cost increases. On the other hand, the manufacturers in many cases offered no price inducement to buy standard equipment as compared to equipment with special features desired by the particular user. In many cases the user suspected the manufacturers of pricing the standard product to take the savings consequent on its adoption, and left the user only the "glory"; and the whole idea of standardization suffered thereby.

The manufacturers are cognizant of this situation, and there have been some excellent examples of the correct handling of standardized products. Outstanding are the price reductions offered in the last few years in the field of standard metalclad switchgear and the users' acceptance of it. In this, the manufacturers took the lead by reducing the price as a means of increasing the volume, and the result was very gratifying and shows what can be done.

To make the benefits of such standardized production generally available, two steps are necessary. First, the manufacturer must offer a price inducement to the user to "buy standard" and somehow convince him that the process represents a real and substantial reduction in the price of standard equipment and not just an increase in the price of non-standard equipment. Second, the users must make a real effort to agree on standard designs and then buy them. To make this effective, top management will have to let it be known to their engineers and operators that they must show cause for not using standard equipment.

There is another aspect of standardization which is very important and that is the determination of the minimum range of utilization voltage economically acceptable to the industry. If that voltage range can be narrow enough so that a single line of appliances, motors, and the like, will give satisfactory results, the manufacturer can realize the maximum benefit from mass production with a resultant lower cost of manufacture. Some excellent work is now in progress on this subject by a joint manufacturer-utility committee.

In these matters the interest of the manufacturer and the user are identical, and with proper executive support there appears to be worth-while savings. The engineering side of standardization is well on its way, but the commercial side is lagging.

Savings in System Design

Having gained what is to be had in the field of lower-cost equipment, attention should be given to savings to be had in system design. There are very real possibilities in the simplification of systems. It should be borne in mind that, as systems increase in size, they should also be kept simple if ordinary human beings are to operate them, and if operating costs are to be brought down without an offsetting increase in investment.

Again, certain fundamental considerations must be kept in mind. For example: Consider the place of automatic switchgear in a transmission system. If the operating record of transmission lines were perfect, no switchgear would be

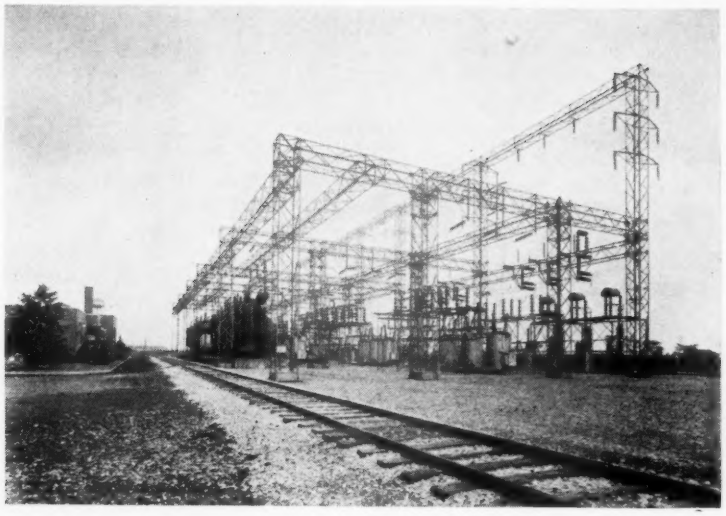


Fig. 3—Left, Automatic Reclosing Air-brake Type Pole-top Switch

Fig. 4—Above, Conventional Type High-voltage Transmission Switching and Stepdown Station

needed other than at the sources of supply. However, they are not perfect; and, when important loads are fed from long lines energized from both ends, it is necessary to sectionalize the line so that the load can be fed from either end in the event of a fault on the line feeding from the other end. It is customary to use automatic opening conventional switchgear for such sectionalization. However, when the lines have thus been sectionalized to the point where the reliability of the individual sections is reasonably high, it is practicable to tap additional stepdown substations directly off the lines without further sectionalization with conventional automatic switchgear. To protect against the few cases in which the tapped section cannot be immediately re-energized, it is customary to install relatively inexpensive hand-operated disconnect-type pole-top switches in the line on either side of the substation tap. Thus, when a line fault occurs on one side of the tap, service to the substation can be restored by manually opening the pole-top switch on that side and then re-energizing the substation from the other line end. For the few cases in which this happens, the substation is subjected to an outage of a half hour or so. If more rapid restoration of service is required, resort can be had to self-reclosing pole-top switches designed to automatically sectionalize the line as soon as the line voltage fails and to automatically reconnect the substation to whichever end of the line the voltage is restored on first. With this type of equipment the substation outage can be reduced to about one minute. In effect, the automatic pole-top switches perform the same function as would be performed by operators if they were constantly standing at the pole-top switches.

Figure 3 shows an automatic reclosing pole-top switch of this kind, and further down the roadway is its companion switch and the substation which the switches protect. On the second crossarm from the top of the pole in the foreground, there can be seen three vertical potentiometer devices which appear somewhat like lightning arresters. These devices are used in lieu of outdoor potential transformers. They are connected from each line to ground, and the pilot voltage for the control of the operating mechanism is shunted off them next to the ground connection. These pole-top switches operate in the following manner. When, for any reason, the line voltage fails, the switches drop open. Whenever the voltage is restored on either section of the line, the restored pilot voltage from the potentiometer device on that section acts to reclose its pole-top switch. The result is that the substation is reconnected to the section of transmission line that first comes alive. As soon as the other transmission section becomes alive, the other poletop switch automatically recloses restoring the continuity of the through transmission line. Several of these pole-top switches have been in operation for a number of years and so far have given very good results. They are very much less costly than conventional switchgear.

With the high reliability of present-day high-voltage transmission lines, similar practice of tapping substations off such lines is also practicable. While reclosing poletop switches have not as yet been devised for use at these higher voltages, their commercial development may prove to be attractive. To set up a bus and sectionalize a high-voltage line in the conventional manner with automatic circuit breakers is costly, both as to investment and operating costs, and elimination of such equipment produces real savings.

Two large stepdown installations, tapped off double-circuit steel tower lines of the 138-kv class, are already in operation on the Detroit Edison system. The lines are fairly long. In one case the distance between automatic circuit breakers is 25 miles, and in the other 50 miles. At present, the disconnecting devices for sectionalizing the lines at the tap points are manually operated. The reliability of these installations has so far been very good; and, if they continue so, it is the intention to make considerable use of this type of installation in the future with consequent large savings.

Figure 4 shows the conventional type of high-voltage transmission switching station. The lines come in overhead and

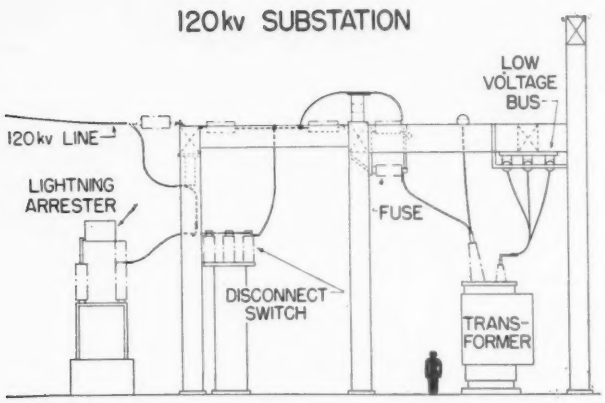


Fig. 5—Diagrammatic Cross-section of a Two-bank High-voltage Stepdown Station Tapped Directly off the Transmission Line

on the ground are the conventional type of circuit breakers. At the left are the stepdown transformers. Contrast this with Figure 5. This figure is only diagrammatic, but it illustrates how the stepdown transformers may be connected to the transmission lines with only a disconnecting switch and lightning arrester interposed. In this particular installation, a high-voltage fuse was used but that is not usually required. For that class of service, two such installations would comprise a transformer stepdown station. Figure 6 illustrates the manner of taking taps off the 120-kv transmission line to feed the transformers shown in Figure 5. There is a tap-off structure for each transformer bank. Each tap-off structure is made with two standard transmission towers connected by cross girders and carries the hand-operated disconnecting switches for sectionalizing its through lines. Reclosing-type operating devices could be applied to these sectionalizing disconnecting switches along the lines illustrated in Figure 3, but so far there has been no call for this complication.

In general, the elimination of any unnecessary switch gear is well worth attempting, even at the cost of some extra line copper and transformer capacity. Extra copper works at all times toward lower losses, but switchgear is always a liability in that its hazards are ever present, despite the fact that it operates infrequently. Also, the maintenance cost of switchgear is very high.

Another opportunity for system savings lies in the very great reliability of modern high-voltage cable. It approaches the reliability of the transformer. Its use as extended generator leads permits the connection of generator terminals directly to a bus at an intermediate switching center rather than to the power plant bus. This arrangement results in lower cost than that required where the output of the generator is transmitted from the power plant at lower voltage. It also has the advantage of reducing the short-circuit concentration at the power plant, and creates a simpler and more easily operated system. Should the cable fail, the generator would, of course, be out of service until repairs could be made, but experience to date indicates that the annual availability of the generators would not be reduced more than one-half of one per cent; say, from 95 per cent to 94½ per cent. A radial generator line, consisting of 120-kv cable having 100,000 kva capacity and a length of some seven miles, has been in successful operation for over two years.

For another example, refer again to Figure 1. That portion of Classes D and E enclosed by the dotted lines (Items G and H) shows the outage effect of wood-pole transmission lines on substations tapped off of them without the benefit of local conventional type automatic switchgear. In most of these cases hand-operated pole-top switches are installed at the substations. If the line goes out of service, it takes the substation with it. On the average, these lines and substations account for an outage of 40 minutes once in every two years. Fortunately, most of this outage occurs during daylight hours, usually late in the summer afternoon, and service is restored before darkness falls. While there are several available remedies which might be applied, the most practical one is to sectionalize the line by the use of automatic reclosing pole-top switches on either side of the substation, as described earlier under transmission. This method is applicable only to substations fed by through transmission lines; that is, lines fed from both ends. To protect substations fed by single radial transmission lines, resort can be had to expulsion tube protection of the line. Experimental in-

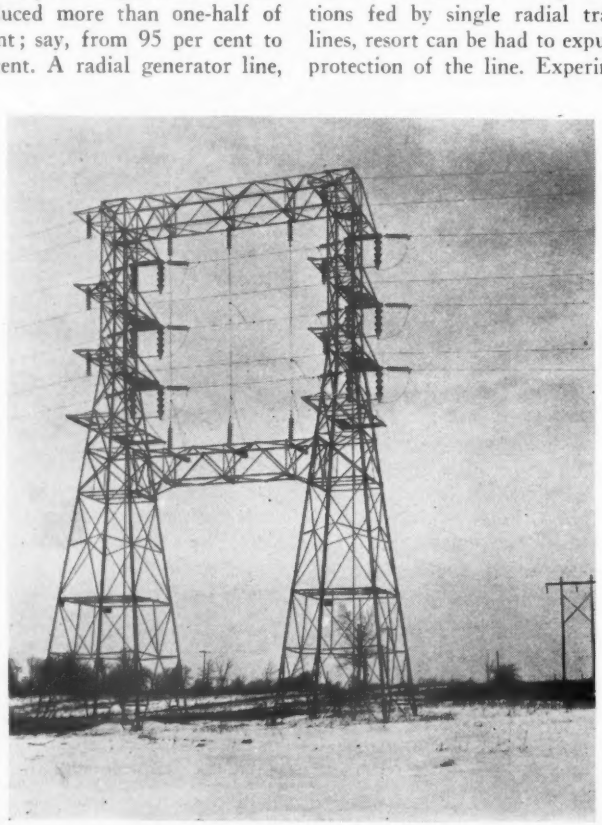


Fig. 6—Tap Connection to High-voltage Transmission Line

stallations indicate that such protective tubes are not required at every pole as was at one time thought necessary. That reduces the cost of such protection to the point where it can be justified in more cases.

While the outage chargeable to transmission lines appears large, by no means does it follow that the cost of obtaining improvement would be justified by the results. As with all such improvement measures, the cost must be weighed against the accomplishments.

Consider next the total of Items B, C, D, E, and F of the several classes shown in Figure 1: These show the outage record of the distribution lines, and tell us what we all know to be true—that distribution lines are, in the aggregate, responsible for more hours of outage than all other causes put together. Also, it is not generally practicable to provide duplicate lines in the interest of reliability. Accordingly, such relief as is economically feasible must largely come from enhancing the reliability of the lines themselves.

Classes B and D show the record of such lines in the outlying cities and towns, and Classes C and E in the rural territory.

The former lines are largely weatherproof wire and readily burn down under power arcs. However, there are switching devices being brought on the market capable of removing the fault current quickly enough to prevent the burn-down of the line unless some foreign object is in contact with it to re-establish the fault. Another promising possibility which will be available after the war is low-cost primary wire of permanently high insulating value. Experimental installations of such wire show real promise.

The distribution lines in Classes C and E are rural and a large portion have bare primary conductor. The fusing of long lateral primary extensions coupled with small low-cost high-speed switching equipment, designed to interrupt the current of transient faults before it can blow the sectionalizing fuses, shows very real promise of marked service improvement at small cost. Such low-cost high-speed switching equipment is now available.

A corollary advantage of the use of these devices is that they should minimize the number of cases of line trouble under storm conditions, and thereby reduce to some degree the number of emergency line crews required. This is becoming a very important matter and a factor which should not be overlooked in considering the cost of applying these remedial measures. Perhaps we can kill two birds with one stone.

In the larger cities, some of the factors which require the putting of distribution lines underground are their proximity to buildings and sometimes their appearance. To meet these conditions, development work on aerial cable for primary use is under way to produce cable which, when it fails, will give visual indication of the location of the fault. Also, some experimental stretches of open-wire lines of much improved appearance have been installed. If these devices can defer the very large expense of putting distribution lines underground, they will accomplish a very real saving.

Steps being taken by the large manufacturing companies to reduce the cost of distribution substations are already well known. The possibilities in that direction are very real, both in first cost and operating saving.

Other examples could be cited, but those given will serve to illustrate.

Operating Savings

It has been common practice in the design of larger switching stations and in generating plant to base the layout on the best equipment arrangement and let the operator get around as best he can. On the other hand, some surprisingly low operating costs have been reported on generating plants designed to require a minimum number of operators. This is an aspect of design which should not be overlooked.

The ability to take equipment out of service for maintenance, without resort to the overtime use of labor is another direction in which savings may be accomplished. Designers would do well to take this into account.

Criteria

How can we tell what we have accomplished? In a rough way, peak load is a measure of ability to earn. Therefore, the final proof of efforts toward lower costs are the system and the operating cost per kilowatt of peak load carried. The trends of those indices are valuable guides in system design. Not only must we watch the design of every larger project, but we must particularly give attention to standard specifications covering the construction of the many small projects, such as, the extension of distribution lines, and the like. A great deal of money is spent on the many jobs which are too small to bear the cost of individual watching and which must be engineered, so to speak, by line crews or small maintenance crews. Periodic review of such standard specifications is an important aspect of system cost reduction.

Under war conditions, the investment per kilowatt of peak has gone to a new low. We can hardly hope to keep it that low with the return of peacetime loads. However, if we use our ingenuity in the application of the means at hand and those forthcoming after the war, its long time trend should continue downward. We engineers have a job cut out for us and the most interesting part is yet to come.

Joe H. Gill

JOE HENRY GILL of Dallas, Tex., president and chairman of the board of Electric Power and Light Corporation and president of United Gas Corporation, died in New York City of a heart attack on June 16. His age was 57.

Born in Kerrville, Tex., a son of William Francis and Miriam Fort Gill, Mr. Gill received an electrical engineering degree from the University of Texas in 1910. Upon his graduation he began his career with the General Electric Company in Schenectady, N. Y. After two years there, he became associated with the Texas Power and Light Company in Dallas in an engineering capacity, advancing to general supervisor of design and construction of electric distribution and transmission systems.

From October, 1917, to December, 1918, he was in the service of the Government, and had charge of electrical design and layout of the power equipment for the American Ordnance Base Depot in France. He entered the Army in March, 1918, and was commissioned as a first lieutenant. At the end of the war he served as an instructor in the Officers Training Camp at Fortress Monroe, Va.

After the Armistice he was employed by the Dallas Power and Light Company, beginning as salesman and advancing to assistant general manager of design, construction and operation of the company's plants and systems.

In 1925 he went to Florida to assist in the development and acquisition of the properties which ultimately became those of the Florida Power and Light Company. He was made vice-president of this concern in 1925 and served as its president and general manager from 1929 to 1933.

In 1933 he was brought to New York by Electric Bond and Share Company to act as senior operating sponsor of those utility properties in the company's system which were situated in the Southeastern area of the United States. In 1935 he became president and chairman of the board of Electric Power and Light Corporation and president of United Gas Corporation.

The Sixth Ingredient—The Heat Pump

The Importance of Its Development in Making the All-Electric Home a Reality

By Philip Sporn

Vice-President and Chief Engineer, American Gas and Electric Service Corporation, New York, N. Y.

Address before the Annual Meeting of the Edison Electric Institute, New York, June 6, 1944

I—Introduction

THERE are five principal services that electricity performs in the modern home today: lighting, refrigerating, cooking, water heating, and operation of miscellaneous appliances or devices. The sixth, and most important function—more important, in fact, than all other five functions put together—namely, heating, is today still performed non-electrically. It can, in most cases, be performed electrically by the heat pump. I hope to show in this paper why this is so, and how it can be brought about. My aim, primarily, is to stimulate interest, on the part of all those responsible for, and concerned with, the development of the residential electric loads on the systems of electric utilities of this country, to a sufficiently high point where they will begin to do something about it. Specifically, I would like to see them do at least a portion of their share of the job that needs to be done if the all-electric home which is so glibly being talked about is to become a reality. For if this job is not done, the all-electric home may continue to be a very much sought after but elusive will-o'-the-wisp. It may, in fact, become less electric than it is today.

II—The Development of Residential Consumption

Fig. 1 shows clearly the history of the increasing use of major appliances by the residential consumer each year since 1924 by indicating the growth in saturation factor of three important load building residential devices, the range, the refrigerator and the water heater. These data are today well known to the members of the electric utility industry. But please note the following: In 1924, that is 20 years ago, there were already in service 304,300 electric ranges, 76,200 electric water heaters, and 63,500 electric refrigerators. In the course of the next ten years, that is, by 1934, the following growth had taken place:

Electric ranges	238%
Electric water heaters	270%
Electric refrigerators	9300%

The growth in the next decade was, or rather will be, as follows:

Electric ranges	209%
Electric water heaters	272%
Electric refrigerators	214%

The above gives us the estimated 1944 figures of 3,170,000 ranges, 1,042,000 water heaters, and 18,700,000 refrigerators, with saturation factors of 11.7% for ranges, 3.85% for water heaters, and 69% for refrigerators.

The effect of these load building appliances on the average residential consumption and the average residential revenue is shown in Fig. 2. This, too, has been plotted for the last two decades. Note that in this period the residential kilowatt-hours per customer have increased from approximately 378 in 1924 to 1,115 in 1944, an increase of 195%. The revenue per customer increased from about $27.25 in 1924 to approximately $39.50 in 1944, an increase of 45%. The revenue per kilowatt-hour thus was reduced from an average of 7.2c in 1924 to an estimated 3.55c in 1944. However, the revenue per consumer was maintained and even somewhat increased by expanding consumption close to 200%. But the increased consumption would never have been possible without the development of the load supplied by the three important load building devices mentioned. To fully appreciate this, all that needs to be done is to examine the series of curves in Fig. 3. These show the portion of the total residential kilowatt-hour consumption per customer accounted for by the three devices, and the residential

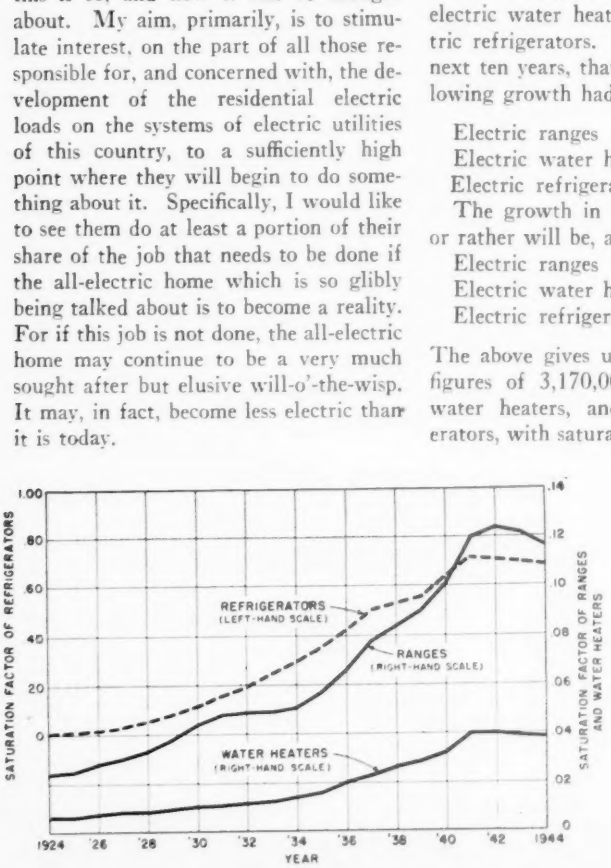

SATURATION FACTOR OF REFRIGERATORS
SATURATION FACTOR OF RANGES AND WATER HEATERS
REFRIGERATORS (LEFT-HAND SCALE)
RANGES (RIGHT-HAND SCALE)
WATER HEATERS (RIGHT-HAND SCALE)
YEAR
1924 '26 '28 '30 '32 '34 '36 '38 '40 '42 1944

Fig. 1—Growth in Saturation Factors of Ranges, Water Heaters, and Refrigerators

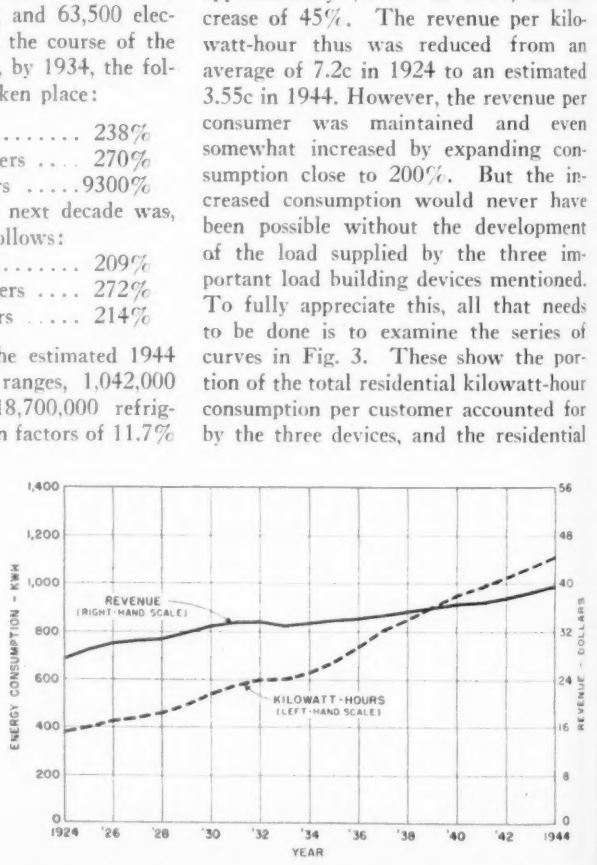

ENERGY CONSUMPTION - KWH
REVENUE - DOLLARS
REVENUE (RIGHT-HAND SCALE)
KILOWATT-HOURS (LEFT-HAND SCALE)
YEAR
1924 '26 '28 '30 '32 '34 '36 '38 '40 '42 1944

Fig. 2—Average Annual Revenue and Consumption per Residential Customer

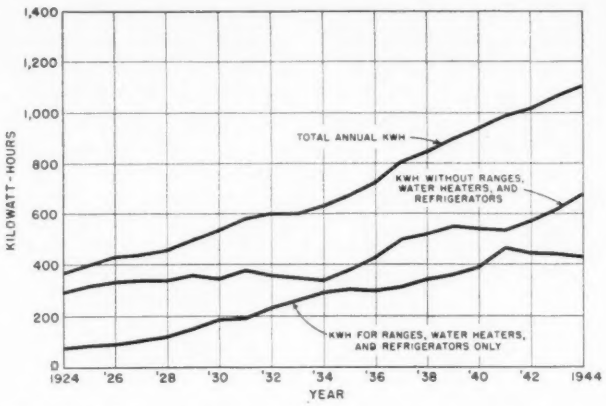


Fig. 3—Effect of Ranges, Water Heaters, and Refrigerators on Average Annual Consumption per Residential Customer

kilowatt-hour consumption per customer without those three devices. Note these two striking points: (1) that instead of the 1944 average residential kilowatt-hour consumption of approximately 1,115 kilowatt-hours, the figure that would prevail without them would be approximately 690 kilowatt-hours; (2) that whereas consumption of all other uses except that furnished by those three devices had a growth in the two decade interval of approximately 130%, the growth supplied by the three devices in the same interval was approximately 444%.

It is interesting to speculate on what would be today's status of the domestic residential consumption if each of the three devices had not been a substantially completed electrical development 20 years ago, a development that had received acceptance to the point that it was being utilized successfully in hundreds of thousands of homes in the case of the range, and in about 70,000 homes in the case of refrigerators and water heaters.

Even more necessary is a study of the effect of reaching substantial saturation, in the case of one of these devices, upon the residential consumption of the next decade, and particularly to find the new electrical device having the same potential effect on domestic consumption as the refrigerator, range, or water heater. And having found it, it is necessary to bring it along quickly in its development stage to a point at least equivalent to that enjoyed by the range or water heater of 20 years ago. It is necessary, in short, to get it into homes and observe its performance as people use it and live with it, and to make further improvements based on such experience so as to pave the way for broad consumer acceptance later.

III—Can We have An All-Electric Home Without Electrical Heating?

There has been a good deal of discussion of the 10,000 kwhr per year residential load as a postwar objective. It is true that the discussion has hinged about that figure as an *objective*, and that the more realistic analysts of prospective growth in residential load have been content with estimating a figure of approximately 1600 kwhr annual average residential use by 1957. But if a real and substantial start is to be made toward the 10000-kwhr consumer it is apparent that devices more numerous and heavier energy consuming than any that have been developed heretofore will have to be brought forth to make possible an annual 10000-kwhr consumption in the average home. That is, if heating is disregarded.

But why should we try to develop a 10000-kwhr consumption without electric heating? Is there any reason why electricity, which admittedly is the cleanest, the most readily available, and the safest form of energy, should not be used for performing the most important single utility function in the average home, i.e., heating and cooling, if it can do so economically, and if there can be developed a demand for it?

Let us take a look at the market that is available from an energy standpoint in the residential homes of the United States if we undertake the job of supplying heating. In Table I[1] there are shown the annual production and consumption of fuels used for heating of residential homes in the United States in the year 1940. This shows a total consumption of fuel for the year for heating of 5038×10^{12} Btu, that is, 5038 trillion Btu. It is estimated that of this amount the annual useful heat is only 2382×10^{12} Btu, which means that only 47% of the annual consumption of fuel is used and the balance of 2656×10^{12} Btu, or 53%, is escaping from the residential chimneys. It is difficult to arrive at an exact figure of what the annual cost of this heating is. But disregarding cost of attendance and repairs, and figuring only fuel cost, one arrives at a conservative figure of $1,682,000,000 for the year. This is almost twice the total electric residential bill of the United States for that year. Why should we not try to develop electric residential heating?

TABLE I—THE RESIDENTIAL FUEL BILL OF U. S. A.—1940

FUEL	INSTALLATIONS		CONSUMPTION		ANNUAL COST
	NUMBER	% OF TOTAL	QUANTITY	HEAT CONTENT BTU	
COAL					
Bituminous	12.58×10^6	36.81	72.5×10^6 TONS		
Anthracite	4.59×10^6	13.45	30.6×10^6 TONS		
Coke	1.53×10^6	4.49	12.9×10^6 TONS		
TOTAL	18.70×10^6	54.75	116.0×10^6 TONS	2787×10^{12}	\$ 870. $\times 10^6$
WOOD	7.76×10^6	22.73	165.0×10^6 CORDS	1454×10^{12}	412.5 $\times 10^6$
OIL	3.43×10^6	10.05	4210.0×10^6 GAL.	526×10^{12}	274. $\times 10^6$
GAS	3.87×10^6	11.32	312.0×10^9 CU. FT.	271×10^{12}	125. $\times 10^6$
OTHER	0.125×10^6	0.37	- - -	- - -	- - -
NONE	0.267×10^6	0.78	- - -	- - -	- - -
TOTAL	34.15×10^6	100.	- - -	5038×10^{12}	\$1681.5 $\times 10^6$

Assumptions: Coal: $7.50 per ton—12,000 Btu per lb.
Gas: (Natural and Artificial) 40c. per 1000 cu. ft.—870 Btu per cu. ft.
Oil: 6½c. per gallon—125,000 Btu per gallon
Wood: $2.50 per cord—3180 Btu per cu. ft.

(1) Developed from a table in "Heating the Post War House" by Robert K. Thulman. Heating and Ventilating—March, 1944.

There is another way of looking at this problem. The annual useful heat (on the 1940 basis) of 2382 x 10^{12} Btu when converted to equivalent electrical units represents an annual energy consumption of 997 billion kwhrs. This contrasts with a total residential consumption estimated for 1944 at 29.7 billion kwhrs. Let us point out at once that even with the many advantages of electric heating, there are very few areas in the country where *straight electric heating* is being used or will be justified for a long time when the relative cost of delivered electric energy is compared with corresponding costs of coal, oil, gas, or other fuels. The heat pump, however, immediately offers a way of eliminating the handicap that electric energy is under when it attempts to enter the residential or commercial heating field on a straight energy conversion basis, and by furnishing heat equivalent to from 3 to 5 kwhr for every kwhr of electric energy used in the heat pump (this is sometimes expressed by saying the heat pump has a coefficient of performance of from 3 to 5), makes possible, and wholly practical, the supplying of electrical heating service to residential and commercial establishments. I shall develop this point in more detail further in this discussion. But it is interesting that if it is assumed that this fundamental advantage of the heat pump, through its so-called coefficient of performance, is maintained at 4½, then the 697 billion kwhr of electric energy equivalent to the annual heat supplied by other fuels now utilized in the United States, could be supplied by approximately 155 billion kwhr of electric energy, and this is roughly 5.25 times the total estimated electric energy consumption of all domestic or residential consumers in the United States in 1944.

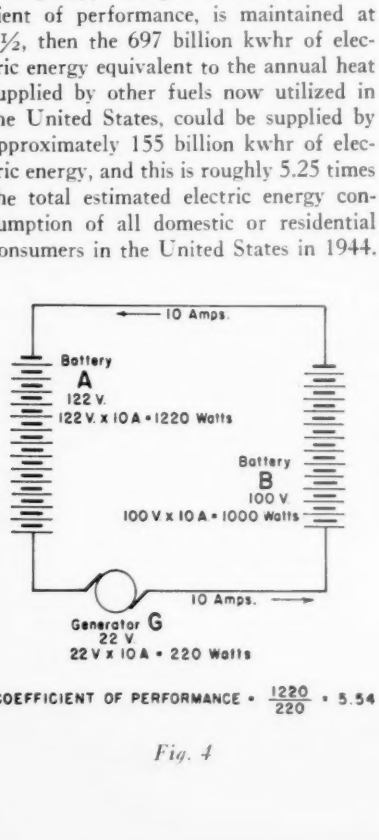


Fig. 4

Here then is at least a glimpse of a road leading to attainment of the 10000-kwhr annual domestic consumption if no further new electrical uses are developed. Why under these conditions, one asks again, should we attempt to do without electric heating in our efforts to develop the domestic market and in our aim to develop the all-electric home? But, you say, that's all very well, but it will take the heat pump to do it. And what is the heat pump? This, therefore, is a good point to stop and answer that question.

IV—What Is The Heat Pump?

The heat pump is not a new or revolutionary idea. It is basically the same thing as the conventional compression type refrigeration system. Such a refrigeration system consists of an evaporator where heat is absorbed from the surrounding space by the refrigerant in changing from liquid to gas, a compressor where the refrigerant is compressed, and a condenser where the refrigerant is liquified, thus giving up the heat absorbed by the evaporater plus the heat equivalent of the work of compression required to sustain the process. The heat pump is nothing more than a compression type refrigeration system with provisions incorporated in the design to put to use the heat given up by the condenser instead of discarding it. The name "Heat Pump" is given to such a design because the heat absorbed at a low temperature level is raised or pumped to a higher temperature level. Since this type of system is basically a refrigeration cycle the same equipment can be used for both heating and cooling.

Please note that in this system heat is absorbed from some source and then heat is added by compression. The source of this absorbed heat can be almost anything—the outside atmosphere, a lake, a river, heated circulating water from a steam condenser, a well or any one of scores of other sources.

When heat is so taken at a temperature T_1 and raised by compression to a temperature T_2, the theoretical maximum coefficient of performance is given by the formula:

$$\text{C.O.P.} = \frac{T_2}{T_2 - T_1}$$

where T_2 and T_1 are expressed in terms of the absolute scale. The C.O.P. above is a measure of the ratio of the total heat obtained by the process to the heat input in the form of work to the compressor. For example, if by such a process heat is abstracted from the atmosphere at a temperature of 60F and is raised to a temperature of 120F (580 abs.), the coefficient of performance would be equal to

$$\frac{580}{60} \text{ or } 9.67.$$

That raises a question, and I have been asked it numerous times: "Isn't this, therefore, a perpetual motion scheme?". The answer is: "Decidedly no, and for the simple reason that it doesn't defy any of the known laws of thermo-dynamics—no energy is created." After all, there is a tremendous amount of heat in the atmospheric shell surrounding the earth alone and another enormous amount in our oceans and the rivers, and both are continually being replenished by the sun. For example, the heat available in the layer of air surrounding the earth (to a thickness represented by a weight of 14.7 pounds for every square inch of the earth's surface) is approximately 830 x 10^{18} Btu, and this represents the heat contained in 57600 years' bituminous coal production, at the rate it is now being mined, in the United States.

The trouble with this heat is that when it is at a temperature of 0 F, it isn't at a temperature level that will make the average person very warm. But there is still approximately 73.3 Btu in every pound of it. The heat pump takes this heat, and by raising it to a higher temperature level, makes it usable for the heating of homes.

Because I have a feeling that this failure to understand the heat pump is in a considerable measure responsible for the failure of many more people to take up the idea, I would like to give another simple illustration showing the compatibility between the idea of the heat pump and other accepted ideas in the electric art, for example. Consider Fig. 4. Here a 22 volt booster generator G is used in connection with a 100 volt Battery B to transfer a charge of 1220 watts into Battery A. The actual expenditure of energy on the part of generator G is only 220 watts for the transfer of every 1220 watts into Battery A. The coefficient of performance of the booster generator in this case is 5.54 but the arrangement is entirely normal. It is perfectly analogous to the arrangement in which a booster compressor is utilized to transfer heat from a source of lower temperature to a receiver at higher temperature.

The actual coefficient of performance obtained in a heat pump system in contrast with the theoretical coefficient of

performance is dependent upon the operating head pressure, the operating suction pressure and the efficiency of the compressor. If the head pressure is high and the suction pressure low, a low coefficient of performance will result; conversely, if the head pressure is lower and/or the suction pressure is higher, a higher coefficient will be obtained. In a heat pump it is advantageous, therefore, to use a heat source with as high a temperature as possible. Well water and/or air are the most generally used heat sources. Well water, when available, provides a constant year round source and is the most satisfactory. Air, on the other hand, varies considerably in temperature and is usually at its lowest temperature when heat requirements are greatest. Nevertheless, air offers the greatest possibility for the heat pump because it is universally available and by using at low outdoor temperatures some form of storage, or some form of auxiliary heat, it can usually be made to operate satisfactorily. This is particularly so in climates where the outdoor temperature seldom drops below 25F.

Theoretically a coefficient of performance of 8-10 is quite possible. But on existing systems the coefficients that have been obtained have varied from 3 to 5.

What kind of operating costs will heat pumps give when used for heating? The following is quoted from a more detailed discussion of the heat pump recently published:[2]

A comparison of the operating cost of a heat pump with a conventional system is rather difficult because operating cost in a conventional system is quite variable, depending upon the type of fuel used, type of equipment employed, and the care with which it is operated. Nevertheless, it is interesting to show even roughly a comparison of the two systems. For this purpose, Table II has been compiled to show the cost of three different classes of fuel when compared with the output from a heat pump at three different costs of electrical energy.

Under conditions assumed, that is, with a coefficient of performance for the heat pump of 4.5 and an efficiency for the conventional heating system of 65%, the heat pump using electric energy at 1 cent per kwhr is fully competitive from an energy output standpoint with 12,000 Btu coal at $10.20 and with 550 Btu gas at 35.1c. But it is important to remember that the cost or trouble of attendance, rather than the cost of fuel, has an important bearing on the choice or rejection of a coal-fired heating system in many buildings. This is borne out by the many houses that are today being heated by manufactured gas at costs in excess of the highest figure employed in the above table: these houses are finding gas heating advantageous because of the elimination of attendance troubles and costs when using gas fuel. It is obvious that under corresponding conditions the heat pump would have the same advantage.

While this analysis admittedly considers only some of the phases of the competitive problem, it does clearly show that with a reasonable coefficient of performance, the heat pump with its special advantages can be brought on a full competitive level with older, less flexible sources of heat.

V—Existing Heat Pump Installations

Have heat pumps been built and are there many of them operating? Answer: Yes, a number have been built and are operating; in the United States there are perhaps 30 or 40 in operation. There are a number of others in Switzerland and in South America. But the number is altogether too insignificant. On the American Gas and Electric Company system there are seven installations and all are furnishing heating in the wintertime and cooling in the summertime, giving year round air conditioning. They are all doing, on the whole, a first rate job, Two of the latest of this group were installed, and are functioning, in office buildings of The Ohio Power Company, one at Coshocton and the other at Portsmouth. Detailed descriptions of these two systems, together with operating and test data will be presented before the semi-annual meeting of the A.S.H.V.E.[3] A portion of the general description repeated here is pertinent to this discussion.

The Coshocton building was erected in 1940, has two stories and a basement, is 88 ft. long by 55 ft. wide and 35 ft. high. It is utilized as a divisional headquarters and as a Commercial Office in the City of Coshocton. Fig. 5 is a view of this building showing the main entrance. Fig. 6 is an interior view of the Coshocton Office Building showing the cashier section, electrical merchandise display space and auditorium. The stage of the auditorium, seen at the left rear, is set up as an all-electric display kitchen, connecting to an electric work kitchen at the rear. Also on this floor are the chief clerk's office, clerks' space, residential sales office, rural engineers' quarters, main lobby and the accounting section. The auditorium can be closed off from the main lobby by means of a movable partition.

Fig. 7 is a view of the heat pump equipment room located in the basement showing the two compressors and some of the refrigerant and water piping. At Coshocton, well water is used as the source of heat. For this purpose a deep-well pump having an electrical demand of 3.34 kw is utilized. The two compressors have electrical demands of 10.2 and 15.65 kw, respectively. There is also a circulating pump having an electrical demand of 1.84 kw.

The Portsmouth building was also erected in 1940. This is a four story building, 104 ft. long by 45 ft. wide and 45½ ft. high. This building is located in a flood area so that no basement was provided. The fourth story is designed, therefore, for equipment usually found in a basement and contains the air conditioning room, the transformer vault and the general storage vault. Like the Coshocton building this serves as a divisional headquarters and as a Commercial office for the City of Portsmouth. Fig. 8 is an east view of the Portsmouth build-

TABLE II—COMPARISON OF EQUIVALENT COST OF HEAT BY HEAT PUMP AND BY FUELS

COST OF ELECTRICAL ENERGY PER KW-HR., CENTS	COST OF FUEL ON EQUIVALENT OUTPUT BASIS				
	COAL, PER TON		GAS, PER 1,000 CU. FT.		OIL, PER GAL.
	12,000 Btu PER LB.	14,000 Btu PER LB.	550 Btu PER CU. FT.	1000 Btu PER CU. FT.	125,000 Btu PER GAL.
1	$10.20	$11.90	$0.234	$0.424	$0.052
1½	15.30	17.85	0.351	0.636	0.078
2	20.40	23.80	0.468	0.848	0.104

Assumed: Coefficient of Performance of Heat Pump—4.5
Efficiency of Conventional Heating Systems—65%

(2) "The Heat Pump—An All-Electric Year Round Air Conditioning System" by Philip Sporn and E. R. Ambrose. Heating and Ventilating—January, 1944.

(3) "Description and Performance of Two Heat Pump Air Conditioning Systems" by Philip Sporn and E. R. Ambrose, to be presented before Semi-Annual Meeting A.S.H.V.E., June, 1944. See also Heating, Piping and Air Conditioning—June, 1944.

Fig. 5—Office Building at Coshocton, Ohio, Having Heat Pump Installation

Fig. 6—Interior View in the Coshocton Building

Fig. 7—Heat Pump Equipment Room in Basement of Coshocton Building

ing showing the main entrance. Fig. 9 is an interior view of the first floor showing the cashier's quarters in the background. The space in the foreground affords ample room and facilities for the various merchandise displays. An auditorium occupies the northern portion of this floor. The stage in this auditorium is equipped with an all-electric kitchen. The credit manager, petty cash, merchandise clerk and chief clerk's offices are adjacent to the cashier's space. The space along the west wall of this floor is devoted to the men's and women's rest rooms, stairs to the mezzanine vault, coat room, elevator and main stairway. These details are cited for Portsmouth, as they were above for Coshocton, to indicate the kind of living that is being done in the building.

Fig. 10 is a view of the fourth floor air-conditioning equipment at Portsmouth showing the refrigerant compressors, control panel, outside air unit, and connecting piping. The three pumps shown in this figure circulate the liquid through the system. The Freon compressor and refrigerant piping are in the background.

I do not wish to here go into details of performance at either Coshocton or Portsmouth. This, as has already been pointed out, is being given elsewhere.[3] But I do wish to abstract some of the general conclusions arrived at after three years' operation, observation of, and tests on these two heat pump installations:

1. The Coshocton system, using water as the heat source, has operated entirely satisfactorily. The average coefficient of performance for the entire heating season is 3.6.
2. The Portsmouth system, using air as the basic heat source, has operated entirely satisfactorily when outdoor temperatures were 20F or above. Below 20F city water is used as an auxiliary heat source. This has given some trouble but not enough to seriously affect the overall performance. The average coefficient of performance for the entire season is approximately 3.0.
3. The coefficients of performance obtained at Coshocton and Portsmouth are about the average which can be expected under corresponding conditions using present day equipment and designs. However considerable improvement in C.O.P. should result as improvements are made in the efficiency of

the compressor and the other equipment making up the system.

All of the above is good as far as it goes. But it is also most disappointing because it must be apparent that, if the results cited here have been obtained, far more impressive results would be possible if extensive development and effort had been put into it commensurate with its potentialities for benefiting the electric industry.

VI—The Heat Pump on the Distribution System

Straight electric heating, it has been pointed out, will, except in isolated cases, find very little application because of (a) the inherent handicap that electric energy, and steam generated electric energy in particular is under when attempting to compete as a source of heat with directly released heat energy, and (b) the heavy distribution costs that a distribution system supplying energy on a 1:1 conversion basis would entail. Fundamentally, the heat pump is in a position to overcome both these handicaps. It has already been shown how coefficients of performance of 3.6 have been obtained, and the basis for the belief that a coefficient of performance of 4.5 and higher can be confidently looked forward to in the future.

What, however, of the distribution problem presented by the heat pump? Let us admit that the problem is not susceptible of exact solution at the present time. Frankly, we do not have enough exact knowledge about the character of the load that would be imposed upon the distribution systems, particularly when the heat pump finds extensive residential application. There are practically no heat pumps in service serving residential types of homes and the information available, even as to the other installations, is limited. As a result it is necessary to speculate on the possible and probable performance using the meager data available, and resorting to engineering evaluations of the known factors of the process.

It is quite likely that, with a 4.2 kw maximum input for the compressor motor and auxiliaries, in a typical six-room house, using outside air as a heat source, it will require about six hours continuous running to bring the house temperature up from 60F to 70F in the morning, on an average winter day. That means that the unit would start at about 4 a. m. and run continuously until 10 a. m. From then on during a day of average winter temperature the unit would operate on a fairly regular on and off cycle. As the

Fig. 8—Office Building at Portsmouth Having Heat Pump Installation

Fig. 9—Interior View of First Floor of Portsmouth Building

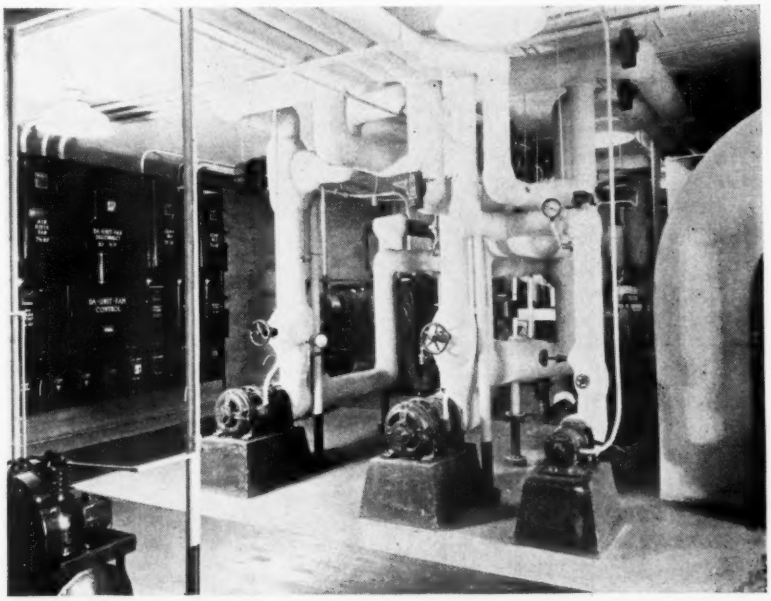
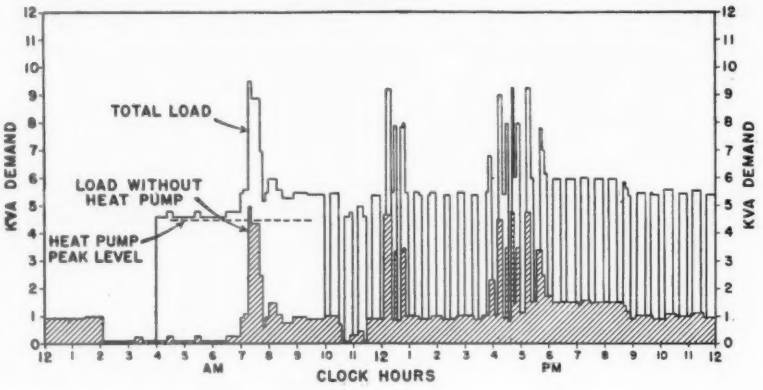


Fig. 10—Air-conditioning Equipment in the Portsmouth Building, Located on Fourth Floor

outside temperature rises during the day, the cycle would gradually change to a shorter "on" and a longer "off" period. In the evening the cycle would probably revert to the kind of cycle experienced during the late morning. From 12 p. m. to 4 a. m., assuming that the thermostat would be set for 60F, the compressor would stay off under average temperature conditions or the operating periods would be of relatively short duration.

During periods when outdoor temperatures are at or below design values the unit would probably run continuously. If, on the other hand, the outside temperature is milder than the average, the load cycle would be such that the on periods would be shorter and the off periods longer than under average temperature conditions. These cycles would vary considerably for different geographical locations and could be varied by varying the size of the unit and the amount of heat storage provided, but the more important economic factors involved would hardly change.

If you plot the typical daily load curve for an average winter day of a residential consumer using all appliances, lights and the heat pump, you would get a curve resembling very much that shown in Fig. 11. Here I have shown in outline the total load curve of this typical modern customer and in the hatched area the load curve of all of the customer's load except the heat pump. A short dotted line on this figure shows the level of the maximum demand of the heat pump alone. While this curve shows a number of sharp peaks when the heat pump demand is superimposed on the peaks of the other load, this is characteristic only of an individual customer. The origin of these peaks is traceable to other loads than the heat pump, loads which we now serve, and whose peaks we know by experience, are smoothed out when combined in larger groups. Because of the inherently high load factor characteristic of the heat pump load there should result an improvement in group load factor as a result of serving the heat pump. It is interesting to note that the individual peak demand on the distribution system capacity imposed on it by a heat pump is less than that imposed by a present day otherwise fully electrified (that is nonfully electrified) home. While it is true that to serve a large number of heat pumps will require a greater system investment than to serve an equal number of customers having all kinds of equipment except the heat pump, this is due solely to the lower coincidence factor, along with the poorer load factor, of the latter type of customer. The expansion of the heat pump load will doubtlessly present some distribution problems. But these should be no more formidable than those that have been presented to the industry heretofore by several of the present heavy energy consuming or heavy demand devices. There is no reason to believe that, with the background of experience available to the industry for serving economically the present class of heavy current consuming devices, there will be any basic or fundamental problem involved in serving economically residential or commercial heat pump applications utilizing properly developed and engineered heat pump equipment.

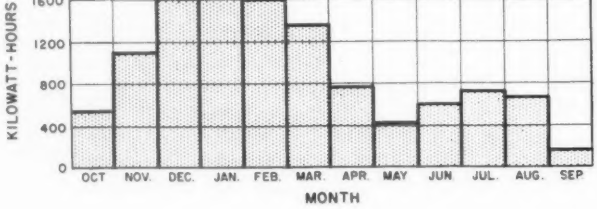


TYPICAL DAILY LOAD CURVE FOR RESIDENTIAL CUSTOMER
ALL APPLIANCES, LIGHTS AND HEAT PUMP
(AVERAGE WINTER DAY)

Fig. 11

VII—What Consumption Can be Expected In a Heat Pump Conditioned All-Electric Home and How Can Such Homes be Brought About?

In Fig. 12 I have shown the monthly kilowatt-hours consumed in a typical year by a heat pump in an average well built six room house in the vicinity of Pittsburgh. The curve is based upon an assumption that the house has a volume of 12,000 cubic feet, that it is well insulated and uses double glazed windows. The heat loss of such a house on a —10F day would be approximately 54,000 B.t.u. per hour. This home could be heated with a heat pump having an average input of 3.5 kw and a probable maximum input of 4.2 kw, provided the average coefficient of performance was 4.5, and an off-peak storage tank of approximately 1000 gallons is employed. This would require a total yearly kilowatt-hour consumption for both heating and cooling of 10,900 kwhr, of which 8900 are heating and 2000 are cooling. This then would make possible a consumption in the electric home of tomorrow as in Table III. Note this: (1) This is based upon existing devices of



HEAT PUMP MONTHLY KWH CONSUMPTION
FOR
AVERAGE WELL-BUILT 6 ROOM HOUSE
VICINITY OF PITTSBURGH, PA.
(INCLUDES COMPRESSOR MOTOR AND ALL AUXILIARIES)

Fig. 12

TABLE III—ENERGY CONSUMPTION IN THE ELECTRIC HOME OF TOMORROW—KWHR PER YEAR

CLASS OF ELECTRICAL APPLIANCE	WITHOUT ELECTRIC HEAT AND AIR CONDITIONING	ELECTRICALLY HEATED AND AIR CONDITIONED BY HEAT PUMP
Lighting, Misc. Appliances	348	348
Refrigerator	312	312
Radios	80	80
Flatirons	64	64
Washing Machine	24	24
Vacuum Cleaners	20	20
Toasters	15	15
Electric Clocks	14	14
Roaster	225	225
Ironing Machine	100	100
Percolators	72	72
Space Heaters	45	45
Water Heating	2,625	1,306
Range	975	975
House Heating	0	8,900
House Cooling	0	2,000
TOTAL	4,917 kwhr	14,500 kwhr

known existing consumptions by everything except the heat pump. The heat pump figures are, however, highly conservative. (2) The use of the heat pump makes possible an all-electric home having an annual consumption of 14,500 kwhr instead of 4917 kwhr by a home using other forms of heat.

Actually the comparison is even more striking than that. For it will be observed that it has been assumed that the use of the heat pump for heating would make possible its use for hot water also, and that the net effect of that would be the obtaining of hot water on an approximate 2:1 coefficient of performance basis, and this would reduce the energy required for water heating by over 1300 kwhr. We have then a choice of an electrified home with a heat pump having an annual consumption of 14,500 kwhr, against an annual consumption of 4900 kwhr in an electrified home without electric heating and cooling. That is, we shall be able to continue to look to a consumption of 4900 kwhr provided electric use holds and expands the position it now occupies in the average home. But what guarantee is there that will continue to be the case? Is there not, as a matter of fact, danger that we will retrogress if we do not move forward and electrify services as vital to the health and comfort of a family as heating and summer cooling?

If what has been brought out up to this point has been sufficiently impressive and convincing to lead you to think that electric heating of homes by the heat pump can be made practical, and that it is, as a matter of fact, the only way that the all-electric home can be made a reality, then at this point there will arise in your mind, or I hope there will arise the question, "How can we bring it about and what should be done? What should we as individual engineers, sales executives, operating managers or utility executives do about it?"

I have given this matter a great deal of thought and I have the following suggestions:

1. Assign some well trained and otherwise well qualified people in your organization to go into the problem, to study it and to follow it. Do this at once. Let them—

2. Invent, or promote, stimulate or help the invention and development of new and better compressors, heat transfer devices, and thus better heat pumps. Most of this work should be done by the manufacturers. Therefore,

3. Establish intimate contacts with every reputable air conditioning manufacturer and see whether you cannot interest him in starting a program of development on the heat pump.

4. Of the group indicated in (3) above, make a special effort to establish contacts with those who are electrical manufacturers. Then make contact with the other electrical manufacturers, big, medium-sized and small, who may not at present be interested in air conditioning. If the bigger manufacturers cannot, or are not disposed to, pick up the idea, perhaps the smaller ones can, and will. The best news I have heard in connection with the heat pump since we first started working on the problem in our company more than a decade ago occurred within the last 30 days, when a mid-western manufacturer of coal stokers informed me that he expected to have 50 heat pump installations in service in homes by the end of this year.

I realize that to carry out the four suggestions above may be a difficult thing to do today, confronted as we all are with a shortage of personnel. But still I cannot believe that there isn't some personnel in almost every organization that is not directly concerned with, or that is non-applicable to, the war effort, and that could be put to work therefore on the problem.

5. Many of you are, without a doubt, preparing plans for postwar construction of office buildings, service buildings, operators' cottages and structures of that kind. Make it a point to see that a heat pump installation is carefully considered in each case and all the factors bearing upon the choice are given consideration and see if a heat pump installation cannot be justified. In that connection do not lose sight of the importance to your own organization to obtain the know-how, the feel, and understanding of the many advantages, but also of the problems and difficulties, and of the means for solving them, presented by heat pump heating and cooling.

6. It may be necessary and desirable to establish contacts and set up some cooperative program with other industries. There are such people as progressive and forward-looking builders of homes and a number of these must be found who could be interested in developing the all-electric home. We badly need the benefit of experience that can come only from building heat pump heated and cooled homes to be occupied by typical American families. We need the experience gained from having hundreds of such homes lived in next winter.

7. Above all, let us keep in mind that there is no time to lose. The gas industry, for example, is not dedicating itself nor its talents and efforts to developing the all-electric

(*Continued on page 272*)

Higher Distribution Voltages for Post-War Loads

By A. E. Silver

Ebasco Services Incorporated, New York City

Address before the Annual Meeting of the Edison Electric Institute, New York, June 7, 1944

BUSINESS is directing concerted thought to negotiating successfully the post-war situation. Utilities are earnestly endeavoring to predict post-war load trends, both as to character and as to growth. Predictions, of course, vary widely, but nevertheless, for commercial and residential areas, add up to heavy demands from load comeback and expansion. I have figures of post-war residential loads composited from painstaking forecasts by twenty-two representative utility companies, showing for 1950 53 per cent increase over 1943. This means, instead of the 1,080-kwhr country-wide average annual residential consumption of 1943 that the 1950 average would be 1,650 kwhr. Many think this very conservative. Load densities will be far greater than ever before. Utilities, in common with other businesses, will be facing high labor costs and taxes. Major changes of practices may well be in order.

Loads Outgrowing 4-Kv Primaries

From the direct-current beginning, facilities for delivering electric service have come forward by steps of evolution. Following advent of the transformer down to approaching the turn of the century, 1,100 volts was extensively used as a primary voltage, and its capabilities were in keeping with the very limited lighting loads of that day. With continuing increase in loads in homes, stores and shops, this voltage was doubled and 2,200-volt primaries met the needs for a decade and more. Then, following the First World War, flourished the next stage of stepping up load-carrying ability at moderate cost—that of Y-connecting the 2,200-volt primary circuits for 4,000 volts, and this has served well for roughly two decades. Now, as we measure the capabilities of this 4-kv system against the loads seriously expected to follow the present war, we find it of inadequate stature. Higher primary-voltage systems in the 12,000 to 14,400-volt range can easily handle these post-war loads.

I wish at this juncture to define a circuit designation that I shall use henceforth for simplification of expression. As found countrywide today, primary circuits in the lower-voltage class are rated at a variety of values, including 2400, 4160 and 4800 volts. Any voltage in this group I shall term 4 kv. Similarly, any rating in the 11,000 to 14,400-volt and even higher range will be termed 12 kv. An exception will be in referring to a specific operating system, when actual rated voltage will be given.

The higher distribution primary voltages have been in successful use many years, serving industrial loads in urban areas, also serving rural areas, including those villages that developed from crossroads' communities after the advent of higher-voltage rural circuits. Notwithstanding this reality, at the present time, a large portion of towns and cities of this country is supplied by long established primary distribution systems falling in the 4-kv class. Physically, expansion still can be accomplished by adding more circuits and equipment of the same type. Furthermore, a question of obsolescence is raised for the accumulated investment in existing facilities. Breaking away from long established practice never is easy. However, utilities on previous occasions have reliantly accepted essential advances in development of our art and can be depended upon to deal soundly with the necessities this time.

For 15 years and more, Ebasco engineers have been identified with studies, made from time to time, of specific urban situations involving long established lower-voltage primary systems. Many of these have shown definite possibilities of cost savings and other benefits from instituting well considered step programs for bringing in a higher primary voltage. Some companies have put such findings into practice by stopping expansion of a 4-kv system and providing 12-kv primaries to take the load growth.

A very good example is Dallas, Tex., the overhead districts of which were served by 4-kv radial circuits supplied from a 13.2-kv sub-transmission system through conventional transformer substations. Beginning in 1937, in lieu of installing additional 4-kv substation capacity, there was undertaken gradual conversion of 13.2-kv primaries. This conversion progressed from the fringes toward the center of supply. Now this 13.2-kv primary system comprises 450 miles of circuit, exclusive of sub-transmission, and serves a large portion of the residential and light commercial areas of the city. This system is rather fully described in a two-part article appearing in last April 1 and 15 issues of *Electrical World*.

Economy

In approaching this higher-voltage project, one of the first questions encountered is whether investment in the lower-voltage system will be rendered obsolete prematurely. Such obsolescence is unnecessary. Also, this change of basic plan frequently can be initiated without increasing the immediate capital outlay over that required for expanding the lower-voltage primary system.

Greatest economy is obtainable where an existing generating and sub-transmission voltage is at a level suited to the primary voltage purpose. This avoids one step of transformation with associated substations. However, in some situations involving, in either case, transformation from a transmission voltage to the primary voltage, studies have shown savings in overall costs for the higher voltage. The chief savings in this latter case must be found within the primary circuits and include lower investment in conductors, savings in energy losses, and savings in pole lines because of fewer circuits. Substation costs are reduced because of fewer circuits and, in some cases, may be further reduced by avoidance of individual circuit voltage regulators.

The higher cost of distribution transformers and accessories, of course, partly offsets the savings but this cost increment is minimized by 7.2-kv phase-to-neutral transformers on four-wire multigrounded common-neutral 12-kv circuits, entirely similar to the conventional 4-kv system. Most of the higher-voltage primary systems with which I am familiar are of this type.

I will refer to one example of cost comparison, roughly typical of a substantial number of cases studied, of continuing urban distribution-system expansion at 4 kv versus gradual conversion to 12 kv:

In 1939, Salt Lake City of 150,000 population was served at 4 kv, for the most part stepped down from 44-kv transmission system. The need was faced for a new substation in a rapidly growing residential section where the area load had reached 4400 kva. A study was made of the relative economies of expanding 4-kv distribution as compared to conversion of the area to 11 kv. This study was projected ahead to doubling of the load in an assumed 10-year period. Estimated annual costs, including fixed charges on investment, operating costs, and costs of energy losses, showed aggregate cumulative savings of $144,000 in favor of conversion of 12-kv primary distribution. A plan for such conversion was adopted. It is emphasized that in this case a transforming substation was required regardless of primary voltage.

Experience

Eleven client companies, upon request, have contributed up-to-date reviews of typical experience in conversion from the lower to the higher-voltage standard in urban areas, with particular reference to operation. I can assure you that these reviews are impressive, but time permits only a high-spot composite of this with other information. The status of conversion in some of the typical cities and towns reported is given in Table I.

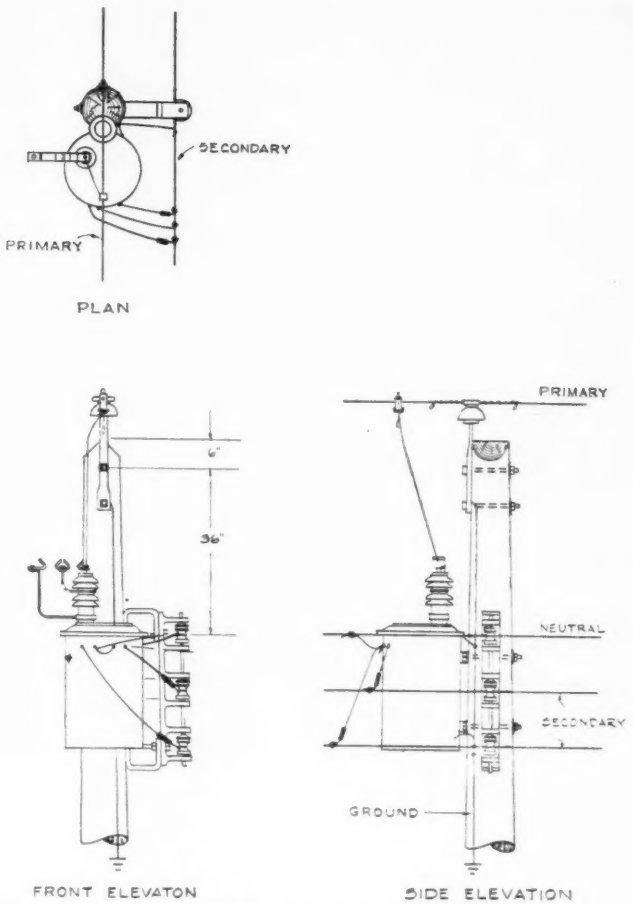


Fig. 1—Standard Single-Phase Lateral, 7.6-Kv. Phase-to-Neutral. Florida Power & Light Company.

Note: Absence of crossarms; single hot primary wire at pole top; common primary and secondary neutral; open double spill gap at transformer bushing for lightning protection; absence of primary cutout circuit, sectionalizing fuses being depended upon.

TABLE I—CITIES AND TOWNS TYPICAL OF CONVERSION TO HIGHER VOLTAGE PRIMARIES

City or Town	Population**	Date Conversion to Higher Voltage Was Started	Present Overhead Distribution System Load	
			Total	Portion at 12 Kv
Sanford, N. C.	9,800	Several years prior to 1940	4,000 kw	100%
Tyler, Texas	28,000	1928	8,500 kva	65%
Nampa, Idaho	12,000	Over 10 yrs. ago	5,100 kw	35%
Twin Falls, Idaho	12,000	Over 10 yrs. ago	3,800 kw	29%
Little Rock, Ark.	88,000	1935	24,000 kw	67%
Jackson, Miss.	62,000	1936	12,400 kw	52%
Dallas, Texas	350,000	1937	50,000 kw	30%
Ft. Worth, Texas	220,000	1937	28,500 kva	20%
Miami, Florida	172,000	1939	36,000 kw	31%
Spokane, Wash.	143,000	1939	39,000 kw	15%
Salt Lake City, Utah	150,000	1940	35,400 kw	10%
Wichita, Kansas	222,000**	1940	21,000 kva	5%
Raleigh, N. C.	62,000	1940	15,300 kw	18%

* In some cases, 1940 census, in others present estimated population.
** Total metropolitan area.

In addition to Tyler, Texas Power & Light Company reported on other towns of over 4000 population—six served exclusively at 12 kv and 10 more partly at 12 kv and partly at a lower voltage. One of the latter, Waco has a population of 56,000, with over one-third of its load served at the higher voltage.

Florida Power & Light Company reported a number of towns and villages served either wholly or partly at 13.2 kv.

Several of the companies reported that many Army Cantonments have employed the higher-voltage primaries for area distribution systems and one company reported several war housing projects similarly served.

Objectives

In practically every case, the chief reason given for embarking on a pro-

Fig. 2—Three-Phase 12-Kv Line Serving Residential District, Fort Worth, Tex.

City-owned street lighting wires and telephone cable on same poles.

Fig. 3—Single-Phase Lateral, 7.2-Kv to Neutral. Fort Worth, Tex.

Joint construction with open-wire telephone circuits.

gram of conversion was economy. In all cases, the program has been based on the avoidance of expansion of the lower-voltage system through area-by-area conversion at the rate required by load growth and by expanded life of lower-voltage equipment. In some cases, one system-voltage level has been eliminated, also in some cases, primary circuits originate directly at the generating station bus, thus avoiding transformation except at the service stepdown.

Another reason is reduction of pole-line congestion. At the higher voltages, in urban areas, distances of feed are much less controlling. This makes handling of load growth largely a matter of taking off circuit branches or adding primary circuits as required. Fewer circuits mean less conductors on poles in vicinity of supply centers, and especially so in areas where the sub-transmission voltage is eliminated.

Some referred particularly to the flat profile with the higher voltage as contributing greatly to quality of service. For the same load, distance and circuit copper, the percentage line voltage drop at 12 kv is one-ninth that at 4 kv. In practice, part of this advantage is delegated to higher loading, greater distance, and smaller copper. By judicious bus-voltage regulation, individual circuit regulators frequently may be avoided.

As in voltage drops, for the same loads, distances, and conductor sizes, energy loss at 12 kv is one-ninth that at 4 kv.

Service Reliability

Many people today appear of the definite belief that with the greater load capacity, greater circuit length and greater geographical exposure relative to lower-voltage primary practice, service continuity must be sacrificed in using the higher voltage. I do not agree.

It is still impractical to avoid insulator flashover and tripout from lightning on distribution circuits. Lightning tripouts are accepted as a matter of course and on many systems circuit restoration is still performed manually. Operating records from distribution experience generally show 85 per cent or more of circuit interruption to originate from transient causes, mostly lightning, as compared to 15 per cent or less that inherently prevent immediate service restoration. By application of modern relays and associated circuit-controlling devices, transient faults can be removed and circuit re-energized with outage duration of only a fraction of a second, and with negligible effect upon the use of service.

It was brought out in the Dallas experience that five circuits aggregating 326 miles encountered 197 cases of tripout, and 25 branch and section fuse openings in one year of operation. One circuit tripout resulted in lockout of 20 minutes, and one locked out a circuit equipped only for single automatic reclosure which was reclosed successfully by hand. Counting the latter lockout among the momentary interruptions, this means that, on the basis of estimated averages for the entire 326 miles of circuit, each customer experienced outage of 20 minutes or more at the rate of once in approximately two years and momentary interruption 40 times per year.

May I volunteer that this calibre of service is entirely adequate for the customer's best interest; also that it is of a higher degree of continuity than is

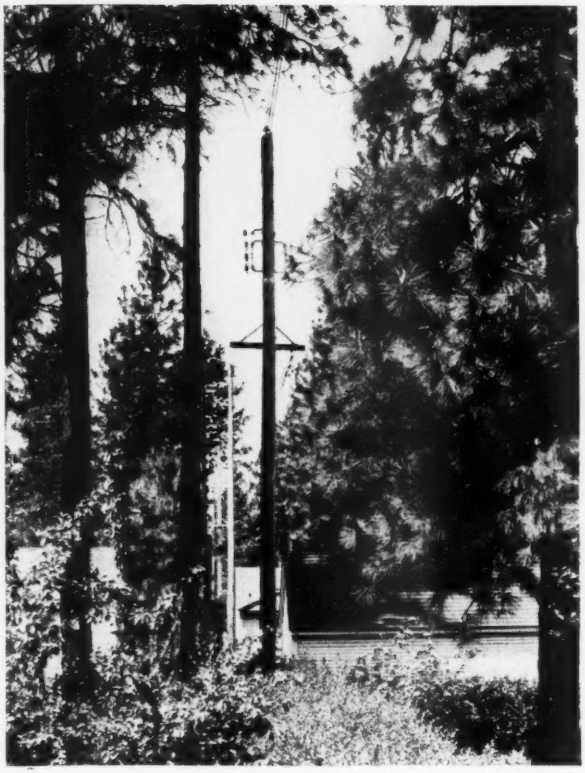


Fig. 4—Single-Phase Lateral, 7.6-Kv to Neutral. Spokane, Wash.

Note, tree conditions; also secondary-rack extension and crossarm support for telephone cable required by state law.

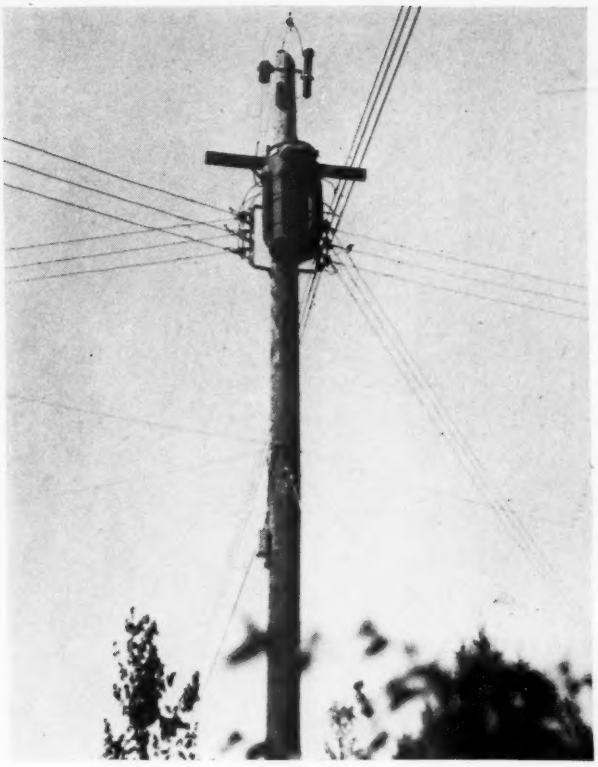


Fig. 5—Single-Phase Lateral, 7.2-Kv to Neutral, Serving Residences.

customarily realized from 4-kv overhead primary distribution circuits in mainly residential areas of high lightning exposure. Furthermore, when service of the order being given in Dallas over single-circuit 13.2-kv radial circuits is practical of accomplishment, it not only is unjustified expenditure but building a vulnerable competitive position to continue adding duplicate facilities and other gadgets addressed to the objective of "always better service." Our constant objective must be to give "adequate" service, but the continual urge to "gold plate" service leads to frequent increments of unneeded investment and maintenance.

Working Lines While Energized

Operation of the higher-voltage distribution circuits involves much the same procedure as conventional lower-voltage systems. All of the companies use live-line tools or "hot sticks" when working lines alive, except one that uses "hot sticks" for some work, and, in good weather, rubber gloves for other work.

Safety records at the higher voltage have been excellent. Safety to the public is most effectively provided by immediately de-energizing any fallen conductors. Circuits at 12 kv "relay out" more positively than do those at 4 kv. No doubt, some accidents to linemen from carelessness have been avoided due to the psychological effect of the higher voltage in promoting care. No evidence of reduced safety was reported by any company. One company reported that linemen consider it safer to work the higher-voltage primaries with "hot sticks" than the lower voltage with rubber goods.

With respect to live-line tools, one of the questions most frequently asked is whether line work is not appreciably slowed as compared to the use of rubber goods on the lower-voltage primaries. Client opinion was about evenly divided as to whether or not increased time is required for given maintenance operations, although pointing out that the time taken to place rubber shields and protectors is avoided in the case of "hot-stick" work. Less overall maintenance is required because of fewer circuits. One company stated that time on the simpler 12-kv lines with "hot sticks" is comparable to rubber gloves on the lower-voltage lines with more numerous wires. One stated that the smaller conductors at 12 kv are easier and less expensive to work than the larger 4-kv conductors with rubber goods. One mentioned that work on dead ends and corner poles requires more time with "hot sticks" at the higher voltage. One company that uses special short-handled live-line tools concludes that the overall time taken for usual types of line work actually is less with "hot sticks." It has been remarked by operating people after a period at the higher voltage that no increase in line crews was required.

Trees

Shade trees probably cause the leading apprehension on higher-voltage distribution for residential urban areas. That this is largely a mental hazard has been proven where the problem has been faced squarely, with determination to find a solution. The fewer circuits and simplified single-phase construction facilitate maintaining clearance, and it usually works out that trees prove no more troublesome at 12 kv than at 4 kv. Majority client opinion rates more tree trimming at the higher voltage, but less faults due to trees with better clearance provided. An exception is in areas where extensive use of tree wire has become

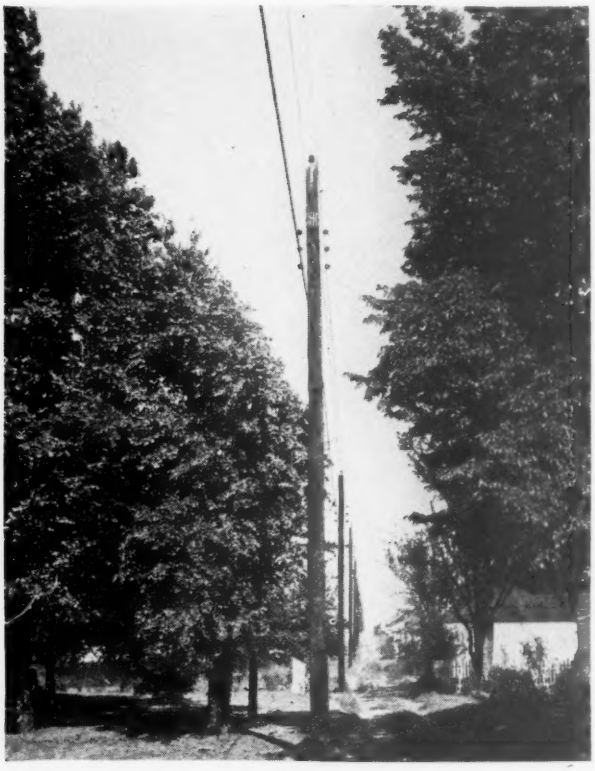


Fig. 6—Single-Phase Lateral, 7.6-Kv to Neutral, Dallas, Tex.

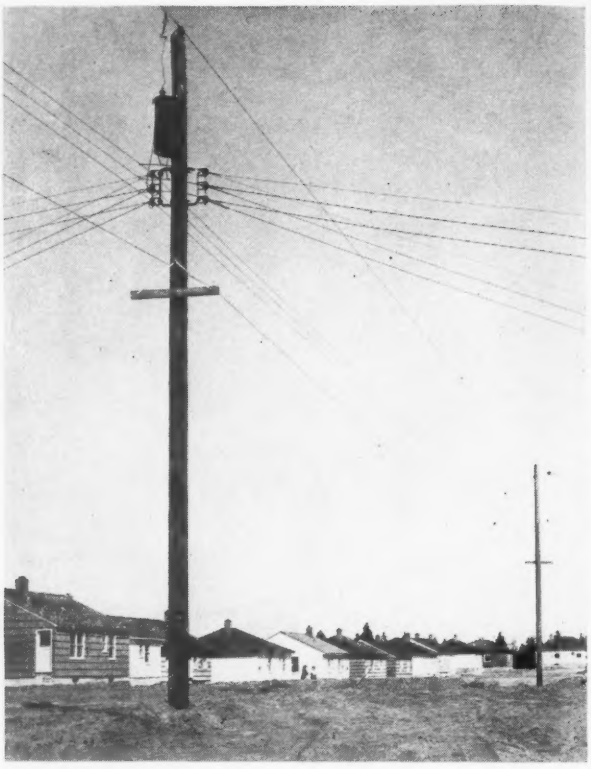


Fig. 7—Single-Phase Lateral, 7.6-Kv to Neutral, Serving War Housing Project, Spokane, Wash.

established as the basic solution. To date, low-cost tree wire suitable for use at 12 kv has not been developed. Aerial cable can be used as a solution for scattered "bad spots" without unduly affecting the economic picture. None of the companies reporting use appreciable amounts of tree wire at the lower voltages.

Joint Use of Poles

Joint use at the higher voltage is practiced in every case, and no abnormal problems were reported.

Joint use at 4 kv is thoroughly established and widespread. It is natural, of course, that increasing primary voltage to 12 kv should call for cooperative reexamination of the measures of coordination. In specific cases, through this course, adjustments have been worked out so that joint use has been continued at the higher voltage with mutual benefits unimpaired. Safety to communication plant and personnel and to telephone users is of first importance. It can be provided by cooperative engineering and basically simple measures, which include:

Rapid relaying of power circuits for immediate de-energizing of a fault.

Fuses in power-circuit branches.

Attention to impedance in the power-system neutral to avoid excessive fault current.

Common grounding of power and communication circuits.

Overvoltage discharge gap (99A protector) on open-wire communication circuits.

Radio Interference

Only one company reported any added problem of radio coordination. This one case was solved by the use of spesial insulators or pins with wooden tops. Two companies reported using special insulators as a precaution.

Street Lighting

What to do with series street-lighting circuits in higher-voltage primary distribution areas may present somewhat of a problem. One solution is to initiate a program of conversion from series to multiple type of street lighting, geared to the program for converting to higher-voltage primaries. This incentive probably will prove a virtue, for there are very many areas where existing street lighting will be outmoded and needing modernization post war.

For urban areas with distribution secondaries generally available, the multiple system offers monetary savings. In residential areas where single-phase primary laterals prevail, multiple street-lighting permits a single hot higher-voltage wire carried on pole-top pin, with maximum simplicity on the pole, pleasing appearance and ease in avoiding tree interference.

I have selected for illustration a few prints typical of this higher-voltage primary distribution practice. These are shows as Figs. 1 to 7.

Summary

In closing may I brief conclusions from the coverage of my subject:

(1) There is general belief that post-war residential and commercial loads will advance rapidly. In many situations, present 4-kv primary distribution systems will stagger under the demands. Bold, advance preparations will be necessary to prevent service from bogging down.

(2) Compared with 4-kv, one available measure for accepting doubled, tripled, quadrupled or even more load, without increasing the amount of copper in the air, is the 12-kv primary circuit. I believe urban distribution-system loading in the industry generally is near the stage that a movement to higher-voltage primaries is inevitable.

(3) Far-sighted planning, with ingenuity, can lay down stepped programs for conversion of primary circuits from 4 kv to 12 kv that will provide adequate service standards with improved voltage, save in aggregate investment and energy losses and with very moderate absolescence.

(4) In operation, higher-voltage primaries,

(*Continued on page* 271)

Modern Equipment Aids System Savings

By A. C. Monteith

Manager, Industry Engineering Department, Westinghouse Electric and Manufacturing Company

Address before the Annual Meeting of the Edison Electric Institute, New York, June 7, 1944

THE electric industry has established an enviable record in the way it has met the demands and requirements created by the impacts of war. Its performance has confounded its worst critics and surprised its staunchest supporters. But it must not rest long on these laurels. The hazards of complacency are well known. The mark of a healthy industry is its progressive growth. Precedents and customs which have reached the limits of their possibilities must be pruned out so that new growth can be stimulated by the light of new and changing conditions.

The coming of peace will bring many new problems to the industry. They will be varied but most of them will involve questions of economy in some form. The ideas set forth in this paper are presented as constructive suggestions intended to further the common interests and objectives of manufacturers as well as power companies in promoting an industry that will be a real servant both to its owners and to the country as a whole.

The steady decrease in price of electrical energy, shown in Figure 1, is a delight to us all. It has stimulated much development in all industries. We are doing things electrically today that have made our way of life better, that would have been impossible 20 years ago.

That costs have not decreased as rapidly as prices is somewhat distressing. There is trouble—serious trouble—ahead if the trends continue as indicated in Figure 1. There must be a reasonable margin between cost and price of energy, if the industry is to remain virile. To increase prices will be difficult, if not impossible. Furthermore, I question its desirability, even if it could be accomplished. The conclusion is obvious. Find methods of reducing costs. This is not easy, for reductions in cost must not be made at the expense of service reliability or by cashing some of the system reserves. A reasonable reserve capacity should be maintained for several reasons, the best of which is to withstand the impact of war and other emergencies, of which we have just had such a vivid example.

Methods of Reducing Capital Costs

Any reduction in capital costs will also affect maintenance, taxes and other costs that determine the overall cost of production. This discussion will only cover capital costs. Methods of reducing capital costs could be the subject of a book. A few of the chapter subjects for such a book might be:

1. Use equipment up to its economic limit of loading, especially for short-time overloads occurring infrequently in case of emergency.
2. Provide wattless capacity at the loads to derive the greatest kilowatt system capacity per dollar of investment.
3. Encourage high load-factor loads, which result in a maximum number of kilowatt-hours for a given system investment.
4. Eliminate spare equipment, where the superior reliability of modern equipment with short-time load capacity or portable equipment can be used.
5. Encourage standardization of methods and equipment to minimize designs, drawings, tools, jigs and fixtures for heavy apparatus and in addition, allow volume production when manufacturing the smaller apparatus.
6. Simplify system layout and reduce component parts of the system to a minimum. This is the chapter subject that will be discussed in this paper.

Simplify System Layout and Reduce Component Parts to a Minimum

The possibility of simplification of system layout and component parts is of utmost importance. The public has been educated to demand a high degree of continuity of service and is so dependent on good service now that lowering the standard of service would be as dif-

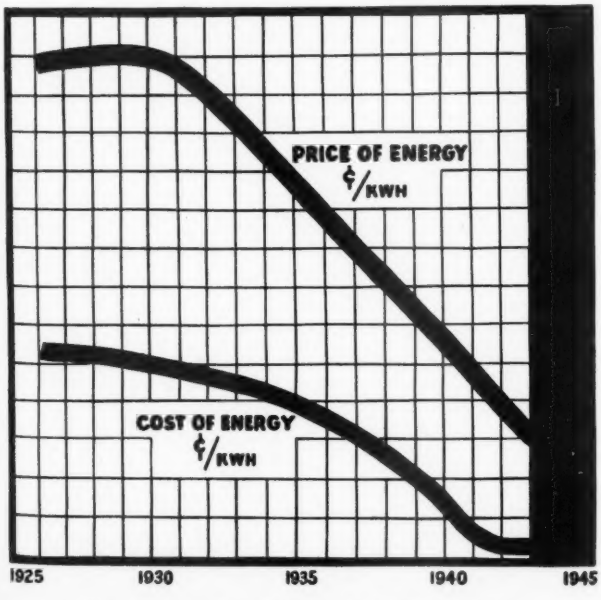


Fig. 1—Trend in Price and Cost of Energy

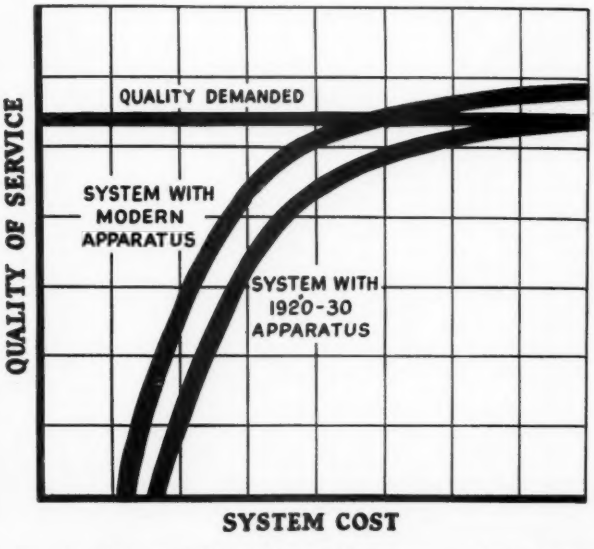


Fig. 2—Effect of Reliability of Apparatus on System Cost

ficult as increasing prices. We should, however, review the system layout now to take into account the improvements that have been made in apparatus and system designs to improve service reliability. This is important because only up to a certain point do increased costs bring improvement in quality of service. Then we reach the point of diminishing returns and costs become excessive for a small improvement in quality of service.

Let us consider the example of Figure 2 which is drawn to illustrate this point and does not necessarily represent any particular system. In this example let us assume that for the equipment available in 1920-1930 it was necessary to put sufficient apparatus, lines, etc., into the system to get the quality of service indicated. But apparatus, line designs, and methods of operation have been improved, so that for systems with modern apparatus, the same quality of service can be obtained at much less investment. This may in many cases be an exaggerated example but it illustrates the point that full advantage of improvements in equipment should be taken when plans for changes or extensions are made. This is such an important point that, before examining specific possibilities, we should briefly review some of the advances that have been made in apparatus and system improvements in the past 20 years.

Apparatus and System Improvements During 20-Year Period

Turbine Generators—Total outage factor has steadily decreased from 15.3 per cent in 1922 to 6.11 per cent in 1941, or maximum possible unit operation has steadily increased from 84.7 per cent in 1922 to 93.86 per cent in 1941.

Circuit Breakers—All modern circuit breakers are now tested at full published kva interrupting capacity in factory laboratories. Twenty years ago designs were based on a few field tests and experience.

Interrupting time has steadily decreased. Twenty years ago the interrupting time of high voltage breakers was about 25 cycles. The first published opening time for oil breakers was 12 cycles in 1929. This was reduced in 1930 to 8 cycles. The published interrupting time of 115-kv breakers and above is 5 cycles, which is approximately one-fifth of the original figure and 3-cycle high-voltage breakers are available.

Breakers are now rated on a 15-second duty cycle and have relatively small derating factors for fast reclosing. This is possible because interruption is accomplished with only a fraction of the arc energy and consequent gas formation. Breakers 20 years ago were rated on a two-minute duty cycle.

High-voltage breakers can be built for reclosing in 20 cycles, a speed impossible only a few years ago. This permits economies in transmission-line construction.

Modern circuit breakers meet the basic impulse levels. Their insulation can be coordinated with other apparatus on the power system so that uniform surge protection can be provided in the station.

Because of the greater corrosive-resisting metals and other improved materials as well as the use of more efficient arc-interrupting devices, modern breakers do not require maintenance and inspection nearly as frequently as did old breakers. Many indoor types of breakers are of the oilless type, which minimize fire and explosion hazards.

Metal-Clad Switchgear — Standardized metal-clad switchgear assemblies are now available utilizing modern breakers and incorporating safety features from an operating point of view that were difficult to get in the ordinary assembly of substation. Where concentration of power necessitates it, the equivalent of segregated phase in metal-clad switchgear can be obtained using only a small portion of the space required for the conventional segregated-phase switchgear. Bus runs are all insulated for full voltage. These bus runs have a practically perfect service record.

System Relaying — System relaying has been improved so that, in combination with the high-speed breakers, faults can be cleared in a few cycles instead of seconds as was the case 20 years ago. Relaying systems have been made more reliable and have been improved through modern methods of application. Overall fault clearing times of as low as 4 cycles are possible. Fault clearing times of 6 to 9 cycles are common.

Transmission Lines — High-voltage outage-proof lines are now in operation as a result of the work done over the past 20 years. Improvements in performance can be credited largely to lowering of tower-footing resistance, more adequate shielding, and coordinated tower designs. High-speed clearing of faults has reduced the burning, usually permitting immediate reclosure. Several lines have been in operation for 10 years with practically perfect operating record. Many lines, 66 kv and above, have had an outage record of less than one per 100 miles per year. The outage factor of one 66-kv line built in 1911 has been reduced from 45 outages per 100 miles per year to three simply by reducing tower-footing resistance. A further reduction to one outage per 100 miles per year would result from adequate shielding.

Low-voltage outage-proof lines are possible through the use of protector tubes. In one case equipping 13.8-kv lines with tubes every second pole on all three phases reduced outages from 42 to 2 per 100 miles per year. Lines can also be built with spacings and conductor arrangements that lend themselves more readily to self-clearing characteristics than do older lines.

Cables—Joints in high-voltage cable have been improved so that there are only approximately one-third the number of cable-joint failures in 1940 as in 1925, whereas in the cable itself, failures are only one-half as likely as in 1925.

Network Transformers — The failures of network transformers per 100 banks per year have been reduced to 30 per cent of those experienced in 1930.

Lightning-Protection Devices—Lightning protection devices are now thoroughly tested in the factory to assure uniformity. Modern arresters will discharge practically a direct stroke of lightning and still protect the apparatus. This is in contrast to the devices built some 20 years ago which would pass only a small fraction of the current that could be encountered and provide protection. This will be discussed in detail in connection with transformers.

Power Transformers—Many developments have led to greater reliability of transformers. Also, the introduction of tap-changing-under-load equipment has made possible more effective use of lines and equipment than with plain transformers. Some of the improvements in the decade from 1922 to 1932 are improved oil, sliverless copper, paper-insulated conductors, brazed coil connections, better gums and varnishes, inert gas to protect the oil from oxygen both in operation and during shipment, and surge proof design. Impulse testing to meet basic insulation levels has been of particular significance. The impulse strength of transformers has doubled in the last 24 years, while the protection ratio of lightning arresters has decreased by one-half, as illustrated in Figure 3. This means that where the protection

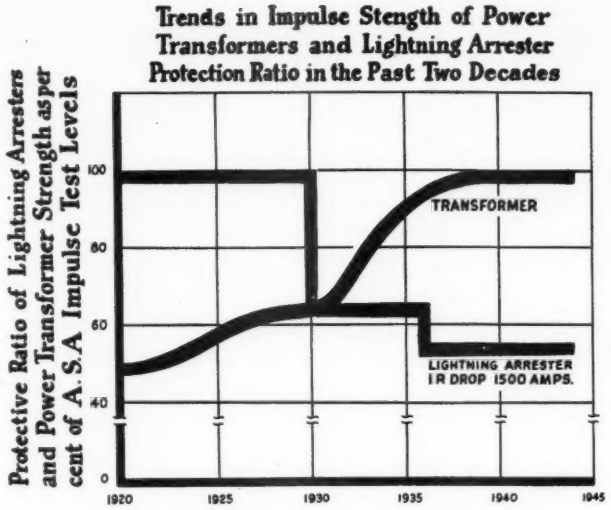


Fig. 3—Trends in Impulse Strength of Power Transformers and Lightning Arrester Protection Ratio in the Past Two Decades

afforded by lightning arresters was marginal or questionable in the early '20s, the present protection devices limit the voltage under similar conditions to approximately one-half of the surge strength of the transformer winding. This gives a large margin of protection ability and therefore a much greater degree of assurance of protecting the transformer under all types of service conditions. Modern protection devices give good protection to many of the older transformers. The methods of applying protection devices are now much better understood than they were 20 years ago.

Since 1932 we have adopted such general improvements as better tank seals, stronger mechanical parts, better bracing of conductors, better insulation through vacuum filling, steep-wave front design and testing, loading by copper temperature, and the air-cooled transformer in classes up to 15 kv. The use of a relay that closely follows the thermal characteristics of the transformer, allowing maximum loading within safe limits, permits greater utilization of transformer capacity.

Auxiliary cooling equipment has been used extensively in the last decade to increase transformer capacity. This allows a normal economic selection of transformers for ordinary operating conditions but provides reserve capacity. Loading by copper temperature utilizes the equipment to its fullest with minimum risk of damage.

Distribution Transformers—As with power transformers, one of the outstanding contributions to more reliable operation of distribution transformers has been the improved impulse characteristics. Full advantage can be taken of this through the use of lightning protection devices capable of discharging most direct strokes of lightning. In 1,900,000 transformer years of service the field failure rate of the protective devices used with transformers of modern design has been 6/1000 of 1 per cent per year. In the last decade distribution transformer failures of all types including windings, protective devices, etc., dropped from 8/10 of 1 per cent failures per year to 1/10 of 1 per cent on a particular group of transformers.

With the conventional methods of protection used approximately a decade ago, outages could be expected on 10 to 20 per cent of transformers each year. With the more modern methods of protection that have been devised, this has been reduced to a fraction of 1 per cent. One company, after a complete review of their transformer troubles, found that 70 per cent of their interruptions in 1942 were caused by lightning. With conventional protection devices they had trouble on 15.7 per cent of their conventional transformers through fuse operations, while with the more complete type of protection, without fuses, the failure rate was but 0.4 per cent.

With the greater reliability of modern distribution transformer they can be loaded higher than was thought possible a decade ago. Within the limits of regulation, system costs can be lowered quite materially through working the distribution transformers up to their thermal limit. Many transformers have been installed whereby the loading limits are determined by thermal devices. In many cases it is possible to use smaller transformers than the conventional type protected with fuses.

General—These examples are incomplete but suffice to show that in the last 20 years the reliability of equipment has materially improved so that it should be possible to modify our thinking in connection with the equipment that is put into systems and still maintain a high degree of reliability. Also, the pyramiding of probabilities should be eliminated where possible to minimize the amount of equipment necessary to secure a given reliability of operation. If too much equipment is installed in an attempt to secure an abnormal degree of reliability, it is quite possible, actually, to increase instead of decrease the probability of outage. Considering all factors, we should do everything possible in the planning of a system to use a minimum of equipment.

Where to Concentrate Effort

If we accept the above statements the natural question is, "Where can we get the greatest return for a given amount of effort?" In considering this point, let us break the power system into its components: generation, transmission and distribution, being divided 28 per cent for generation, 14 per cent for transmission, and 58 per cent for distribution.

In general, a good job has been done on the generating stations. Attention has been focused on the engineering and building of these because they represent large investments and these investments are made at one time. In the last 20 years the cost per kilowatt of building a large station has decreased even in the face of providing more elaborate means of retrieving BTU's by use of stage feeder water heating, higher temperatures and pressures, etc. Meanwhile, the amount of coal has been cut from 3 pounds per kilowatthour in 1920 to a low of 1.31 pounds in 1942. We can expect some further decrease in fuel cost but it will be slight considering the overall cost of a delivered kilowatthour. The possible further decreases in station cost are also small.

Transmission systems also have been built up of relatively large incremental investments so that considerable effort has been concentrated on the engineering and building of these lines. The net result is that little reduction can now be

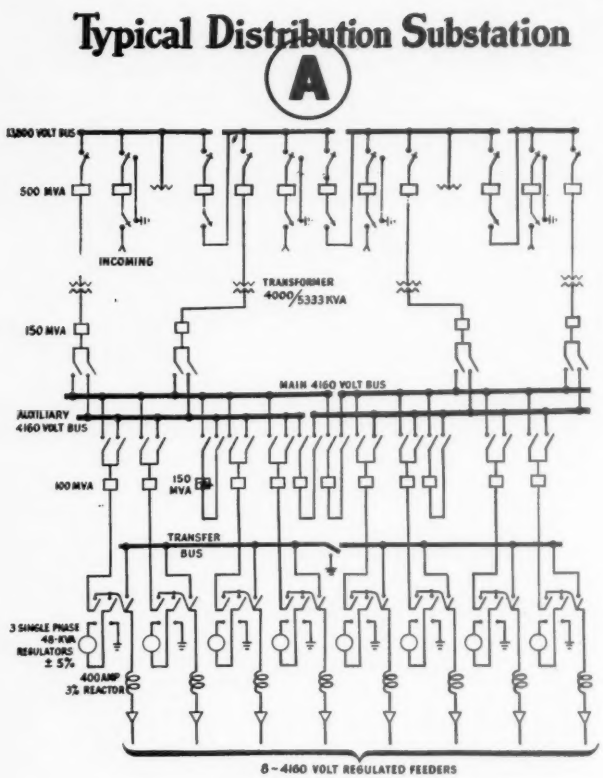


Fig. 4—Typical Distribution Substation

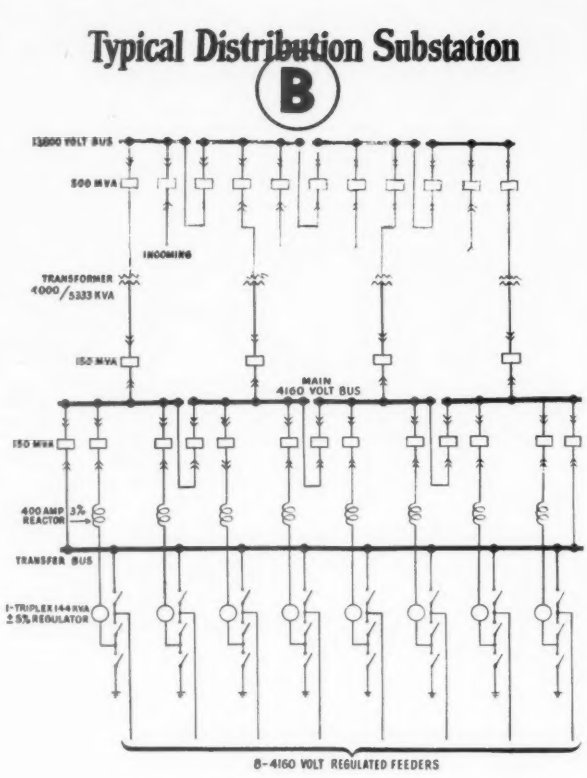


Fig. 5—Typical Distribution Substation

made in the transmission system. The capacity of a few systems can be increased by addition of high-speed relaying and by revamping breakers for faster operation. Series capacitors can be used to neutralize the reactance of the system where the conductors are large enough to carry the increased load. The total possibilities for savings in transmission, however, are minor in comparison to what has already been done.

Approximately 58 per cent of the cost of an electric light and power system is in distribution. In general, distribution systems have been built up of small increments, sometimes purchased by different branches of the organization and put together and operated. The tendency has been to emphasize perfection of service.

Some of today's standards of distribution are predicated on apparatus as it performed 20 years ago. Consideration should be given to the modernization of our thinking on the system as a whole and particularly the distribution system, taking these factors into account. I believe it is possible to minimize the equipment in the distribution system to lower costs when making changes or extensions and still retain the quality of service demanded.

In thinking of how to lower distribution costs a number of schemes are available. The central-distribution substation can be used or small distribution substations can be distributed at many points on the system. In feeding industrial loads, loop feeders with elaborate tap point equipment can be used or radial feeders with multiple feed or a number of combinations with their varying degree of cost can be used. The selection will depend on the importance of the customer process and the size of load. Again in the residential and commercial areas consideration can be given to radial systems, low voltage network systems or primary network systems depending on the load density and the type of service to be furnished. In other words, there are a large number of schemes which can be used in furnishing service to your customers, no one of which is the universal answer.

A typical distribution substation, which will be substation "A," is provided with multiple high-tension buses and main and auxiliary breakers on the secondary bus and a transfer bus for cutting regulators in and out of service as shown in Figure 4. Also single-pole operated breakers have frequently been used so that one line is opened on a single-phase fault. In other words, with a 2000-kva feeder only 666 kva would be lost for a single-phase fault. For the purpose of discussion, the equipment cost of this station will be taken as 100 per cent or $22 per kva of firm demand at the substation (which will be the basis of comparison of all kva costs). This station does all that a distribution substation should do but its cost is high. Some of the features that lead to its high cost are: the use of single-pole switching on the 4-kv primary feeders and the individual voltage regulation on any phase. Most companies have found these refinements unnecessary. The use of 4-kv auxiliary and transfer buses and the many disconnecting switches, to minimize the time of a service outage should a failure occur in a substation, and to facilitate maintenance of equipment, is expensive. In the light of equipment available in the '20s this might have been justified, but with modern equipment this station is more elaborate than necessary.

The introduction of standard metal-clad switchgear with removable multiple operated, three-pole breakers and the use of triplex regulators result in considerable saving. Substation "A" has been modified to permit the use of this mod-

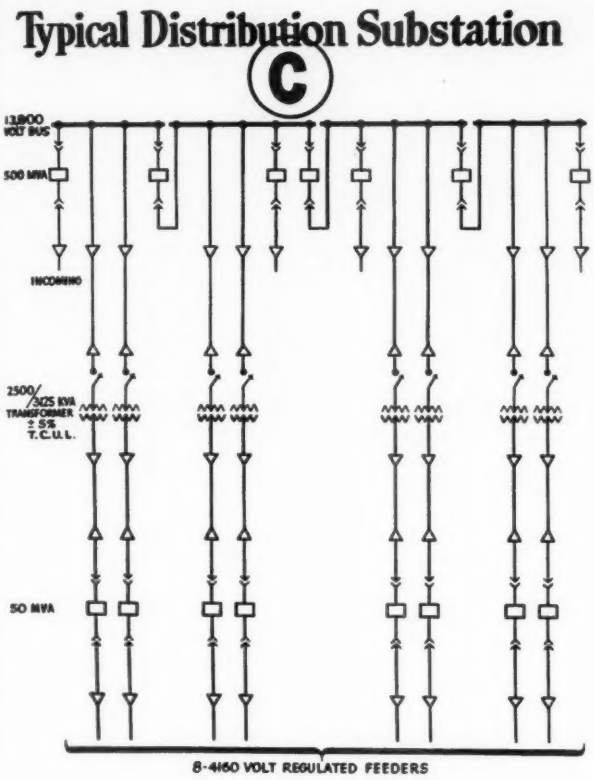


Fig. 6—Typical Distribution Substation

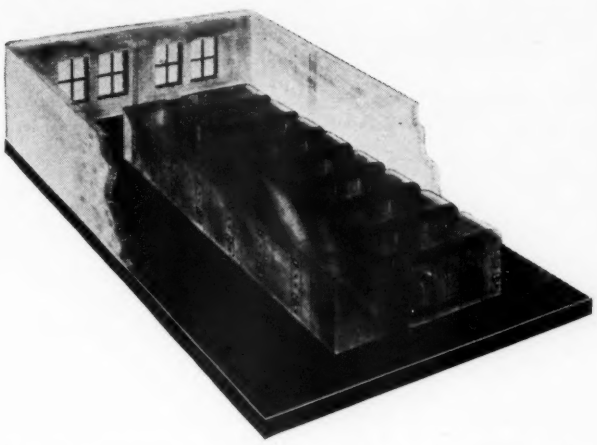


Fig. 7—Isometric View of Equipment for Substation "C"

ern equipment which becomes substation "B" shown in Figure 5. This substation and the one of Figure 4 are identical in performance except for three-phase feeder operation instead of single-phase operation. This results in a substation cost of 63 per cent or $14 per kva. Installation cost, although lower than that for the first substation, will be relatively high when building and wiring costs are included.

In addition to the use of modern standardized equipment, further cost reductions may be made by changing the fundamental substation diagram. Substation "C", Figure 6, illustrates this point and can be used in building new substations or rebuilding old ones. Except that no 15-kv substation transformer breakers are used, the 15-kv switchgear layout is basically the same as that of substation "A". It has been modified only in detail to utilize standard metal-clad switchgear. Beyond this point, however, this substation is unlike substation "A". It is designed on a 4-kv unit feeder basis. There is no 4-kv bus in this substation. With this type of distribution, employing relatively large circuits, facilities must be provided outside the substation on the 4-kv feeders for switching the load of any feeder to two or more adjacent feeders so as to restore service quickly following a feeder failure. Because these facilities must be available elsewhere in the system, even a 4-kv transfer bus has been omitted from substation "C". External switches are utilized when it is necessary to take a substation transformer out of service. Any circuit breaker can be withdrawn from its compartment and a spare breaker inserted. The outstanding advantages of substation "C" are simplicity, unit design with accompanying flexibility for load change, decrease in possible 4-kv short circuit current and the accompanying system voltage disturbance, lower losses, and its lower cost. The equipment for this substation will cost approximately 54 per cent of that of substation "A" or $12 per kva.

The appearance of this equipment when installed in a substation building is shown in Figure 7. The high-voltage, metal-clad switchgear with air circuit breakers extends across the front of the building. To it are bolted the feeder units, each consisting of an air-cooled transformer with automatic tap changing under load and a 4-kv air circuit breaker. The use of air transformers permits installation of all equipment indoors. This makes possible the unit type of construction shown where all connections between the different pieces of equipment are made with short sections of metal-enclosed bus. This type of equipment eliminates many potheads, cables, and conduits required when oil-cooled transformers are used outside the substation building. This type of construction allows complete flexibility in the installation of equipment as the load grows or the moving of equipment should the load decrease.

The location of all the substation equipment indoors naturally raises the question as to the size of the building required to house it. From Figure 8, showing the floor plan of a building to house substation "A" and substation "C", the considerable difference in apparatus costs and cost of installation is apparent.

The transformers and voltage-regulating equipment of substation "C" cannot be as conveniently de-energized for maintenance as in the case of substation "A" without the dropping of load. This is because, as pointed out, load must be switched outside of the substation from one feeder to others. Where external feeder switching equipment is not available, this substation can be modified to substation "D", as shown in Figure 9, to include a transfer bus, thereby permitting all switching for maintenance of station equipment to be done in the station. Thus, to obtain the greater convenience for maintenance provided in substation "D" as compared to substation "C", the station equipment cost has been increased approximately $2 per kva, with a slight increase in building and installation costs.

This discussion so far has been directed to indoor substations. However,

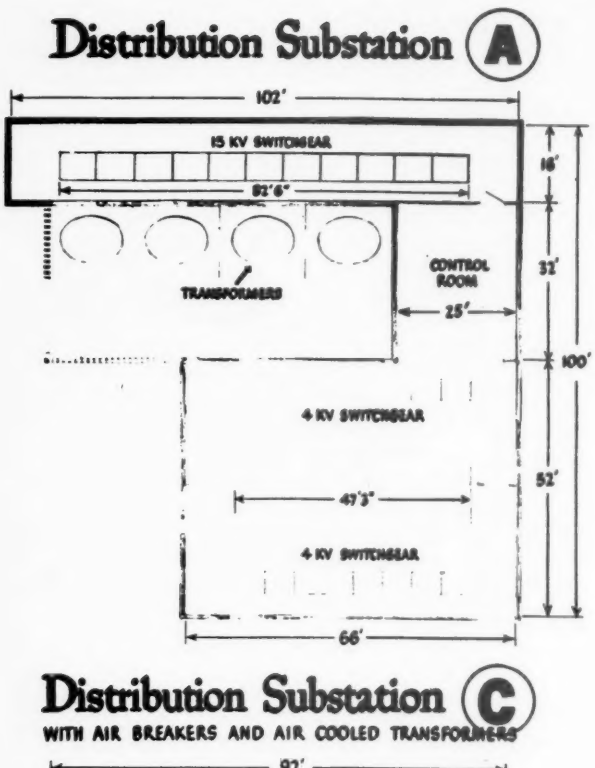


Fig. 8—Floor Plan Comparison of Substations

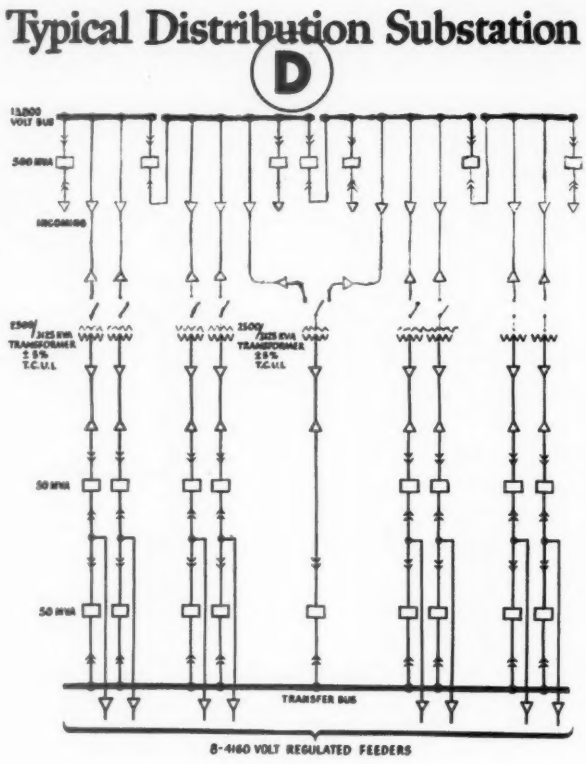


Fig. 9—Typical Distribution Substation

these substations can be constructed with outdoor equipment. In the case of substations "C" and "D", the equipment arrangement and cost will be approximately the same whether installed indoors or outdoors. Outdoors oil-insulated transformers have been substituted for the indoor air-cooled transformers. The substation space will be increased about 25 per cent because of the increased size of the outdoor transformers.

Where new designs and the greater reliability of equipment and lines are taken into account, combining installation and equipment costs result in a substation costing less than 50 per cent of that of the more elaborate substations designed and built on the basis of former service records and experience with the older types of equipment.

Why then can substations "C" or "D" be considered when substation "A" was once deemed necessary. Reviewing the data given on reliability of apparatus and lines, the 4-kv cables have only about one-third the probability of failure now that prevailed in the '20s and transformers have been improved even more. This alone justifies a change from single phase to three-phase operation as the outages per customer caused by cables and transformers should be about the same or even less. The complicated bus arrangement of yesteryear was provided so that feeders could be switched in case of failure of equipment in the substation itself. The probability of failure of equipment in the substation has been minimized because of the complete factory testing. Metal-clad switchgear with complete enclosure of all live parts, air-insulated transformers with tap changing under load and air circuit breakers throughout allow placing all the equipment together in one building. The necessity of single-phase regulation in all cases is questionable.

These same arguments hold for open lines as for cables. Overhead lines are now being built with self-clearing characteristics, but if faults still persist, the vast majority are cleared by de-energizing the feeder and service is automatically restored in a few seconds.

Industrial Power Supply

Another opportunity for economy is in the equipment for distribution systems serving small and medium-size industrial customers. Many of these are supplied from high-voltage loops as shown in Figure 10. One practice is to supply each of a number of industrial substations with equipment as shown in substation "J", which will be the basis of comparison for all schemes. This and all other substations in Figure 10 are designed to serve an industrial customer having a load demand of 1000 kva. Substation "J", costing $22 per kva, provides excellent service to the customer. A loop fault on either side of the substation does not cause any interruption to service. A failure of the transformer will, of course, interrupt

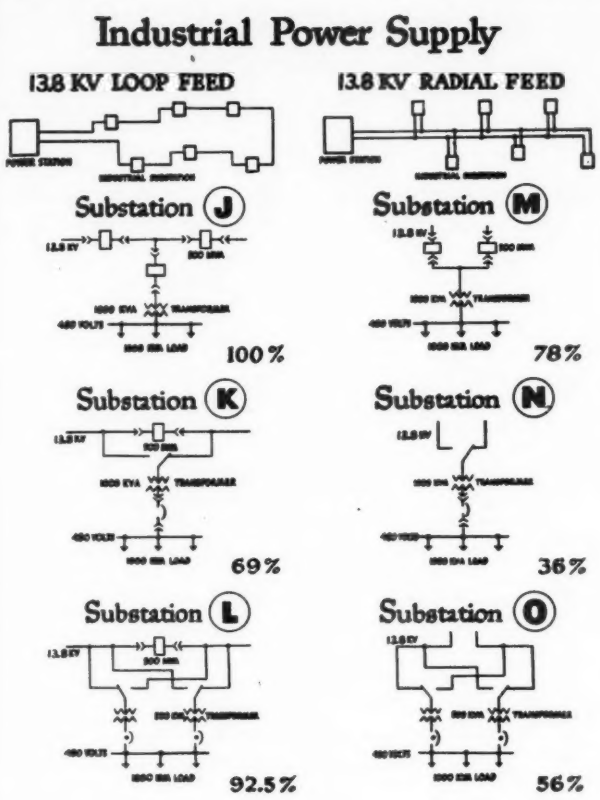


Fig. 10—Industrial Power Supply

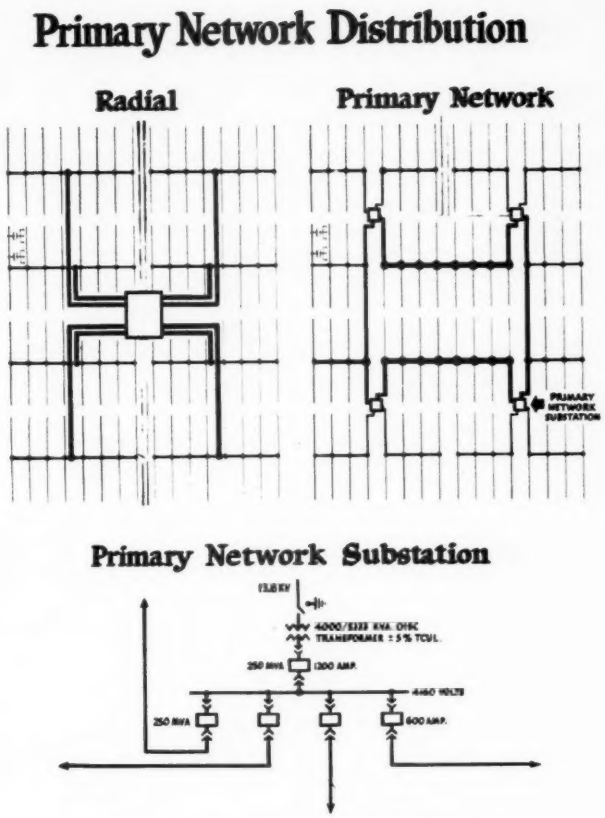


Fig. 11—Primary Network Distribution

the power supply until a good transformer is connected in its place. Transformers are so reliable, however, that additional expense cannot normally be justified to prevent a service interruption that will probably not occur once during the life of the substation. Substation "J" probably gives better service continuity than can be economically justified for many industrial customers.

The probabilities are that a fault will occur about once every five years on one of these industrial loops. If so, substation "K", costing about $15 per kva or 69 per cent of substation "J", can be used to provide adequate service to the great majority of industrial customers. If a fault occurs on the 13.8 kv loop to the right of substation "K", the customer's power supply is interrupted but his service can be quickly restored by opening the circuit breaker in the secondary leads of the transformer, closing the transformer primary switch to the left to connect the transformer to the good section of the 13.8-kv loop, and reclosing the air circuit breaker. Except in this one case of trouble, which probably will cause interruption only once in 15 to 20 years, substation "K" provides substantially the same quality of service as does substation "J" and has an overall saving of about 30 per cent.

The few customers requiring best possible service continuity can be supplied most economically through substation "L". This substation gives somewhat better service than substation "J" at an equipment cost of approximately 92.5 per cent or about $20 per kva. By using substation "K" for 90 per cent of the industrial customers and substation "L" for 10 per cent of them, instead of using substation "J" throughout, an aggregate saving in industrial substation equipment cost of 29 per cent can be made.

A further saving in investment can be made by using two radial feeders to supply a group of industrial customers, as shown on the right of Figure 10. Using this radial supply scheme, the length of cable required will be anywhere from equal to about 50 per cent more than that required when using the loop supply, depending upon the geographical location of the customer served. The possible reduction in size of cable and the fact that both radial feeders can be carried in one duct bank, however, will make the cable supply costs for either loop or radial feeder about equal. Therefore, the savings in substation costs when using the radial supply represents a net saving. Substations "M," "N," and "O" are comparative to those discussed for the loop feeders. When using the radial feeder and substation "N" for 90 per cent of the customers and substation "O" for 10 per cent of the customers, a saving of 62 per cent in substation equipment cost is made when compared with using the 13.8-kv loop feeder and substation "J." Even if substations "K" and "L" are used, as recommended with the loop feeder, the saving in substation equipment cost is 47 per cent if the radial feeder and substations "N" and "O" are used. The radial feeder and substation "N" make it economical to supply in this manner many small industrials now supplied through the large distribution substations along with the residential and small commercial customers. This will release distribution-substation capacity for residential load growth.

Primary-Network Distribution

The predominant method of supplying power to residential and small commercial customers is over radial circuits from relatively large distribution sub-

stations, as shown in Figure 11. To secure the best economy with such a distribution system the substation should be located near the load center of the area it serves. If this is not done, the lengths of the main 4-kv feeders become excessive. This increases both the investment in these circuits and the system losses, which are reflected in increased operating cost. The substation must be located and built before the area it is to serve is well developed. Because distribution-system loads are continually growing and shifting unpredictably, a substation can seldom be located where it should be, to economically serve its load five or ten years after it is built. Also, to move a large distribution substation and make the necessary circuit rearrangements to meet changing load conditions is expensive.

The primary-network system is more flexible. In it a much larger number of relatively small substations are located at or near what would be the load centers of the 4-kv feeders in a system using large substations. These substations are tied together on their 4-kv sides, as shown in Figure 11, to provide service at least comparable to that rendered by the radial system. The equipment cost of one of these substations using outdoor equipment is about $11 per kva compared with $12 for large substation "C." The fact that these small substations can usually be located outdoors with only a fence or a wall around them makes their cost advantage even greater, because the large substation building cost must be added to that of its equipment. When using a primary-network system the cost of the 13.8-kv circuits will usually be greater than when using a radial system such as we have been discussing. In most cases, however, this will be more than offset by the saving in the 4-kv circuit cost. The small primary-network substations can be installed when needed and can be moved from one location to another as changing load conditions dictate. Thus, system investments can be made to follow load requirements closely. Lower losses are also in favor of the primary network. The primary network should be seriously considered for serving residential and small commercial customers whenever a system extension or major change becomes necessary.

Secondary Network Distribution

Secondary-network systems in areas of high load density are now accepted. Greater use of this type of system could be made to lower distribution costs. Small commercial loads with relatively high load density exist in many spots throughout city areas. These areas, now being fed through distribution substations as shown in Figure 12, can be given better service in many cases at less cost from small secondary networks supplied directly over 13.8 kv circuits of the type shown in the figure. The secondary network eliminates one voltage transformation and thus frees distribution substation capacity for residential and small commercial loads. A network protector on each transformer bank results in higher cost than a transformer in the straight radial system as illustrated in Figure 12. The total equipment cost in the network system will be less than in the radial system, however, because there is no distribution substation cost to be included for this scheme. For example, based on the cost of equipment shown in this figure and the costs for substation "C," the equipment cost per kva of demand at a customer service will be about $8 for the network system and about $11 for the radial system. This shows a saving in equipment cost of about 20 per cent in favor of the secondary network. The total saving will often be greater than this when the substation land and building costs and the circuit costs are included.

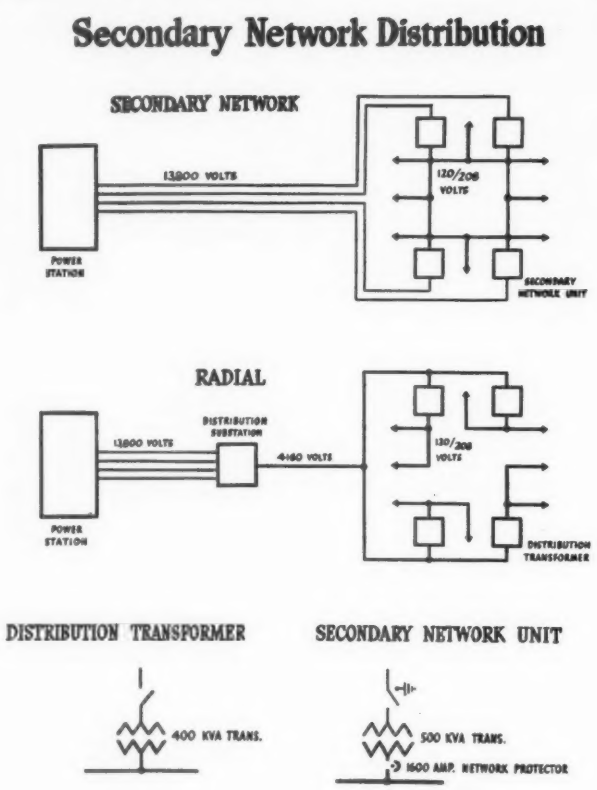


Fig. 12—Secondary Network Distribution

Summary

If as careful engineering is done in connection with distribution as has been done with generation and transmission schemes, the system arrangement can be simplified and still render the service demanded by the customers. Equipment and lines have increased in reliability over the last 20 years to the point where simplified substations and systems can be considered that would have been entirely impractical from a service point of view two decades ago. This will mean less equipment accompanied by a decrease in maintenance and other costs.

This is just one chapter of the book on power system economies that the industry will have to write for itself if it hopes to maintain its illustrious record of high quality service and low prices for its goods. These ideas are presented in the hope that they will promote increased study not only in the distribution component of power system—where the most promising money saving prospects lie—but also in other parts of the power system as well.

Discussion of Mr. Monteith's Address

By R. E. Moody

Vice-President, Union Electric Company of Missouri

MR. MONTEITH has in his paper made another contribution to the interest that manufacturers have lately displayed in the cost of our utility systems and equipment—this time in the field of transmission and distribution rather than in power production. The stimulation of mutual interest on the part of manufacturer and operator is refreshing and should in my opinion be encouraged and intensified. I do not intend to discuss the technical aspects of the paper but wish rather to comment on some of the broader economic aspects outlined by Mr. Monteith and to emphasize specifically their relationship to our problems.

It seems trite to mention that we are in a bitter struggle with the public power advocates but these days one can hardly avoid the fact and surely we should not. Is it too pessimistic to say that public power will continue to be vigorously pushed even if political trends are to the right and free enterprise is staunchly defended? I do not believe so. My suspicion is that many rather conservative minds tend to make a distinction between free enterprise and public ownership of utilities and also that it is often politically expedient to encourage the distinction.

We are presently engaged in a determined effort to tell our story to the public through printed advertising and the radio. It is absolutely necessary that we do this, but I am convinced we cannot fight all of our battles in *The Saturday Evening Post*. Our own territory is also our battleground and our physical property and operating results must be among our weapons. Our engineers, designers and operators need to join the fight along with our publicity men. Unfair as our competition is we must do our best to meet it because unless and until we do we steadily lose ground. This means we must make further major reductions in cost added to a job already well done.

I say this in all seriousness for three reasons. First, our story to the public will be effective just to the degree our performance supports it and no more. If we can back up our sales people with reduced costs reflected in lower rates they, if properly trained, can go to town for us and do a real public relations job which will be something to talk about.

Second, I have an uneasy feeling about our operating results. A number of factors have collectively worked in our favor lately to soften the effect of greater taxes, increased costs of labor and materials, and lower personal efficiency. Some of these favorable factors have been a steady decline in interest rates and as an incident to the war a great improvement in load factor and volume of sales, and perhaps an attendant high level use of machinery and equipment that cannot be permanently sustained. I am afraid that if we look behind these favorable factors we will find a disturbing upward trend in other costs of operation.

The leverage of future unfavorable shifts in these trends may well produce a magnified adverse effect on our operating costs during the next few years with drastic results to our net.

Third, I wonder if all of our operators and engineers are fully familiar with the kind of a job we really want them to do. If I were not convinced that top management has too often been careless about discussing the business side of the industry with engineers and operators and too frequently negligent about framing specific policies I would gladly steer clear of this subject. Engineers and operators inherently strive to render a perfect service measured in terms of voltage regulation and energy continuously available at the point of use. What value our customers place on this component of quality of service relative to cost and other components of service is difficult to answer. It undoubtedly varies greatly with classes of customers—reliability being of the greatest importance to industrial customers. The question is one, it seems to me, that management must explore—perhaps by surveys and other means—and having reached an answer, must determine a policy for the engineers and operators.

Personally I have two rather strong opinions on this subject. One is that for the large numerical groups of customers —that is residential and small commercial—the treatment accorded by our employees who meet them in business transactions far outweighs an occasional flicker of lamps or an outage of short duration, and the other is that because we have not made full allowance for the improvements in equipment and apparatus as pointed out by Mr. Monteith we have reached a point where refinements to provide reliable service have often been installed in excess of their value to the customer. I have a further feeling, backed by some experience, that if we make an intelligent determined effort to further reduce our costs we will be surprised to find that the quality of service will not noticeably depreciate.

I would like to add to this discussion just a few specific remarks on the reduction of operating expenses by means of lowered investment.

Fixed capital is purely a relative matter and paradoxically the more we reduce our investment and its fixed charges along with our other operating expenses the greater our total fixed capital is likely to become. This is simple enough because if we can provide a service at lower cost the increased demand for the service will require us to enlarge our facilities.

Keynesian economics which have become rather fashionable now hold on the other hand that we have reached a period of economic stagnation—that the opportunities for use of new capital will not be sufficient to absorb the country's savings and that we must therefore spend ourselves into maintaining our existence.

This hardly seems probable so long as human wants are greatly in excess of our present ability to satisfy them even in peace times. We know that the demand for electricity can be stimulated in time to a point greatly beyond our present output including the war load. Lower costs, plus salesmanship will create this demand. Thus, if we reduce our operating expenses, lower our investment costs, increase the volume of business with the same investment or add investment to save operating labor or make other economies, we in reality kill two birds with one stone—we increase our business and create further investment opportunities about which some of our economists are so worried and at the

(*Continued on page 272*)

Depreciation Accounting Innovations From the Viewpoint of the Investor

By Philip L. Warren

Investment Adviser, Boston, Mass.

Address before the Annual Meeting of the Edison Electric Institute, New York, N. Y., June 6, 1944

THE only justification for adding to the discussions of this whole subject of Depreciation, especially in the midst of a world crisis, is that the National Association of Railroad and Utility Commissioners, at their convention in August, are considering the adoption of principles of depreciation accounting which are of the utmost importance to the Utility industry and to the investors who have provided the necessary funds to build the industry to its present high efficiency, and who in the future must continue to do so.

Any discussion of Depreciation from the point of view of the investor must take into consideration the basis of all investment: that is, Confidence. If there is a lack of confidence on the part of the investor, either in the industry or in the management of that industry, his dollars will be attracted elsewhere. Every dollar seeking investment has open to it hundreds of opportunities—or to put it another way—every industry and every management requiring capital is in competition with every other for the investor's dollar. When the investor decides to put funds into a regulated industry he must not only have confidence in the industry and its management, but he must have confidence that he will receive fair treatment from the regulatory bodies, and that the rules will not be changed suddenly, and certainly not without just cause. The Utility industry is always in need of large sums of capital; in fact, it takes seven times as much capital per dollar of gross earnings as the average industrial concern. Accordingly, it must keep the investor's confidence and it must have the cooperation of the regulatory bodies so that the investor will maintain his confidence in them also.

Certainly the investor has every reason to have confidence in the Utility industry as a whole, and in its management, as the record over a great many years has been amazing. Its record during this war in supplying one of the prime raw materials for munitions has been outstanding. The industry has not only served the consumer and met his every requirement at steadily lower costs, but has so improved its credit that it has been able to raise funds by senior securities at relatively lower and lower rates. There has, however, been apparent a lack of confidence on the part of the investor; evidenced by the fact that during the past decade there has been practically no new capital attracted to the industry through the issue of Common stocks.

There are undoubtedly many complicated reasons for the relative preference for other industries over the Utility industry in the mind of the investor. The fact remains, however, that good operating company Common stocks are selling at prices today that yield an annual return considerably higher than that obtainable from equally good Industrial stocks. In the great deflation of prices which took place in the market from November, 1929, to July, 1932, the Utilities, as a whole, acted much better than the Industrials, and continued to do so until January, 1933, when the market for Industrial stocks began its slow but steady rise out of the depression. Utility stocks, from the first of January, 1933, to early 1935, dropped seriously in price, and while there has been considerable improvement during the past year in the relation of Utility prices to the prices of Industrial stocks, the Utilities have never recovered to a point where it has been possible to economically finance new money through the issue of Common stocks.

The serious decline in values during 1933 and 1934 reflected a lack of confidence on the part of the investor, which was brought about in large part by the fear of Government competition, and also the growing tendency of regulatory bodies to substitute new theories of accounting and finance for the experience of the past. It was during this time that the regulatory bodies were adopting new ideas as to what constituted a fair rate base, and the whole theory of Original cost was developed. The investor on the street was undoubtedly shocked by the exposure of accounting methods used by some of the less reputable holding company managements. Institutional buyers and larger investors, however, who had been conscious of this situation, were more concerned over the effect they could foresee in the general adoption of the theory of Original Cost. These investors had never desired to take any advantage of the consumer through arbitrary write-ups in value. They knew too well that any such advantage could be only temporary and would react eventually on themselves. They were, however, considerably shaken when they bgan to realize that the values underlying their investments, which represented prudent investment by the managements, could be taken away from them if it could be proved that someone in the dim past, who first devoted this property to the public service, had made an honest profit in its sale to the present owner. The fear of the results of the adoption of such a theory undoubtedly had a depressing effect on Utility stocks, perhaps even greater than was justified.

The Utility industry is now faced with a new theory—the theory of Straight Line Depreciation, and the possible application of this theory retroactively. So far as the theory of Straight Line Depreciation can be properly applied, no real exception need be taken to it. When, however, the theory includes in its application all depreciable property and requires that the resulting reserves be deducted from the Original Cost of this Plant in arriving at a fair rate base, then this theory becomes impracticable.

While the large institutional buyers of Utility securities are fully aware of this development and its probable implications, they are not, by and large, buyers of Utility common stocks. The small investor, the man on the street, has only the foggiest idea concerning Depreciation, and many of his advisers are not much better informed. Accordingly, there is no indication as yet in the mar-

kets of any great fear of such a theory or its results. Those who have had experience in the operation of properties, and those institutional buyers and investment advisers, who realize what may be the result of the adoption of any such theory, are deeply concerned, and they may well be.

None of these people expect or want to take any advantage of the consumer. Certainly management wants to render the best possible service at the lowest possible rate. This rate, however, must be sufficient to take care of all ordinary operating expenses (including taxes and current maintenance) reasonable charges for depreciation, and an over-all rate of return that will make it possible for the Utility to finance itself with a well balanced capital structure.

Throughout the history of the Utility industry, with all the discussions of fair rate of return, replacement value, prudent investment, original cost and the endless rate cases that have been fought out along these lines, there has never been any question as to whether or not the Utility is entitled to include in the rate something, let us call it Depreciation, which takes care of the loss of service value not restored by current maintenance. The amount of this yearly charge and the size of the reserve built up to take care of this so-called Depreciation have been the subject of intense study for many years. There would have been no need of this had replacements actually necessary come along steadily, for then the amount of these requirements would have been apparent. The long life of some utility equipment has made it impossible to set up definite life expectancy tables, and recent studies of the Institute have indicated that over 80 per cent of actual retirements during the past 30 years have been caused, not by slow and steady depreciation which might be figured on a life expectancy basis, but have been caused by inadequacy or obsolescence.

The studies of the Committee on Depreciation Principles of The Edison Institute are particularly valuable in view of the fact that they cover the actual replacements required by operating electric light and power companies with an aggregate property value of some two and one-half billion dollars—over a long period of time aggregating about 561 company years. These figures indicate that with annual credits to Depreciation Reserve averaging 2.25 per cent of Total Plant over the long period covered by the study, the reserve has been built up to 20 per cent of Total Plant after providing throughout the period the funds for all retirements as the need for them developed. The figures further show that the reserves during the 33-year period have practically quadrupled in relation to the plant during a time when the cumulative rate of growth has been steadily dropping. This growth was 7.75 per cent per annum, compounded for the last 30 years, while it was only 5.04 per cent for the last 20 years, and 2.30 per cent during the last decade. Also the study shows that the per cent of current plant needed for retirements of property has not been increasing but rather decreasing during the past 20 years, the average rate for the last 10 years, ending 1943, having been 1.16 per cent as against 1.37 per cent for the decade ending 1933. The only conclusion that can be drawn from these realistic figures, based on actual experience, is that the charges for depreciation made by the companies studied have not only been adequate but may be greater than will have been proved to be necessary during the next decade.

Mr. Samuel Ferguson, of Hartford, has done some very constructive work on this whole theory of Depreciation and has developed an approach to a solution which appears to be most realistic. You are all undoubtedly familiar with his concept of the size of Depreciation Reserve necessary. He makes one point, however, which cannot be over-emphasized in any discussion of the subject; that is that this Depreciation Reserve does not measure the exact amount of loss of service value to date but is really an insurance fund to take care of future replacements as they may become necessary. Accordingly, the size of the reserve must vary with each individual property and must, by its character, be based on experience and good business judgment. It is essentially an engineering and operating problem rather than a mere accounting problem.

Mr. Ferguson's concept that the Depreciation Reserve is essentially an insurance fund brings out, perhaps, the most important consideration from the investor's point of view. If it could be assumed that this Reserve is exactly adequate, no more and no less, certainly no one could argue that the amount of this Reserve should be deducted from the Plant account in figuring a rate base upon which a fair return could be earned. No industry should be penalized for carrying adequate insurance.

Unfortunately, this concept of the Depreciation Reserve does not appeal to many in high places in our regulatory bodies. The feeling is growing that a utility is not entitled to earn a fair return on its Plant but that the Depreciation Reserve should first be deducted, and Net Plant used as a rate base. It is easily demonstrated that in a utility which is static in growth, straight line depreciation under this theory will, over a period of years, result in a 50 per cent Depreciation Reserve. It is here that the investor asks a simple question—Why should he put $100 into Utility plant, be restricted to a 6 per cent return on that investment and then find a few years later that he is allowed to earn 6 per cent on only $50 of Plant? It is perfectly obvious that he has lost one-half the earning power of his investment, and one-half of his actual investment, unless by some means he has had this half returned to him in the way of a dividend in liquidation. Due to the character of the business this is impossible, and accordingly the net result will be, under this method of operation, that the consumer will acquire that half of the property lost to the investor.

This has been pointed out very clearly in a recent memorandum on Depreciation, by applying this formula to a simple class of property subject to a single rate. Let us assume an original cost of $15,000 in street lighting equipment, with a life of 25 years under commission life tables, and a depreciation rate under the straight line method of 4 per cent per annum. The first year the property is put into service the Rate Base under Federal Power Commission Rules would be—

Original Cost	$15,000
Contributions	0
Materials and Supplies	50
Working Capital	90
Rate Base	$15,140

Income at 6%—$908.40 per annum.

At the end of 12½ years, the Depreciation Reserve would have grown to $7,500 and the Rate Base would then be—

Original Cost	$15,000
Contributions	0
Materials and Supplies	50
Working Capital	90
	$15,140
Less—Depreciation	7,500
Rate Base	7,640

with income at 6 per cent of $458.40, or about 3 per cent on the original investment.

Let us see what would be the effect of such a policy on a typical Utility

company with an estimated average property life of 40 years, and with a capital structure consisting of 50 per cent bonds, 25 per cent preferred stock and 25 per cent common stock. Let us assume an original Rate Base of $10,000,000, financed through $5,000,000 of bonds, $2,500,000 of preferred, and $2,500,000 of common stock. At the end of 10 years, the entire equity of the common stockholder would have been wiped out, and in another 10 years the entire equity of the preferred stockholder would have disappeared, leaving the bondholder with just enough Rate Base to cover the face value of his bonds. Certainly no investor would risk his funds in any of these securities on such a theory.

The intelligent investor wants to know that his investment in plant is being maintained and also that the consumer is paying something in his rate which will set up a sufficient reserve so that the investor's capital will not be impaired. If he can then be reasonably confident of a fair return on his investment his money will be attracted to the industry. The first tangible recognition of the fact that the open market for securities is the best criterion of the adequacy of the return is to be found in the plan for adjusting rates agreed upon recently by the New Jersey Power & Light Company and the New Jersey Board of Public Utility Commissioners. This is a frank attempt to arrive at a rate which will attract Common stock money and thus maintain a proper capital structure. The rate base originally agreed upon is to be adjusted annually by adding the cost of additions and betterments and subtracting the cost of actual retirements with certain adjustments for depreciation which recognize the factor of observed depreciation. This is a step in the right direction but the entire benefits which may be derived from this plan would be completely lost if the theory of Straight Line Depreciation and the deduction of the Retirement Reserve had been fully applied, without compromise, in figuring the rate base.

More cooperation between the Commissions and managements, of the kind that led to a solution of this recent New Jersey rate case, would assure the investor that untenable and confiscatory theories of accounting, such as we have been discussing, would not be adopted. Management and the regulatory bodies are jointly responsible for the maintenance of the credit of the industry for the benefit of both the consumer and the investor.

Utilities' Rivalry Waged in Seattle

By Thomas P. Swift

In *New York Times*, July 9, 1944. Copyright, *New York Times*.

THE public power group in the Pacific northwest has no intention of easing up in its drive for extended public ownership of electric utilities, despite the fact that this campaign has been stymied to a considerable degree since the war started.

A striking illustration of the feeling that exists between the public and the privately owned utilities in the Pacific northwest region with respect to the ownership and operation of electric power facilities is provided in the annual report of the municipally owned Department of Lighting of the City of Seattle, Wash., released yesterday.

In this report, signed by E. R. Hoffman, superintendent of the project, the Seattle city plant declares that "competitive waste" still continues in Seattle's electrical utility operations due to the duplicating system of the private power company, the Puget Sound Power and Light Company. The report then adds that the city council has adopted unanimously a resolution calling upon the city to expand its municipal plant so as to take over the entire electric business of the city when Puget Sound Power's franchise expires in 1952.

Competition for Customers

Puget Sound Power and the city municipal plant have been at loggerheads for years in a competitive scramble for residential and commercial customers within the city limits. The private company now handles about 40 per cent of the gross electric business in the city, with the remainder going to the municipal plant. Rates charged by both systems are far below the national average, while usage is well above the national average level. Puget Sound Power in addition serves a large territory outside Seattle.

In 1943 the Seattle lighting plant did a gross revenue business of $9,144,582, according to the report, compared with $8,312,884 in 1942. Its net income transferred to surplus for the year amounted to $851,981, against $711,816 the year before. The plant's total assets were listed on the balance sheet at $86,633,024.

With respect to taxes paid by the Seattle plant, virtually all go to the State and city coffers, the State receiving $263,256 and the city $195,808. Taxes paid to the Federal Government are found under the heading "Federal Transportation Tax" and the amount involved is $44.38. As in the case of all utilities utilizing water power, the plant paid last year a Federal license fee of $18,689.

Difference In Taxes

It is at this point that the privately owned and business-managed utilities clash sharply with publicly owned plants. Private utilities are taxed heavily by the Federal Government, much in the same manner as all other private enterprises, but public and municipal power projects escape the burden of Federal taxation. Puget Sound Power, with consolidated assets of $130,662,960, is paying Federal taxes, in addition to State and city levies, at the rate of more than $2,200,000 annually. This is in sharp contrast to the $86,633,000 Seattle municipal plant's directly traceable Federal tax bill of $44.38 Puget Sound's total tax bill for 1943, according to its annual report, was $3,834,330.

Apparently preparing for a showdown fight with the public power group over the issue of ownership and operation of Pacific Northwest power systems, Frank McLaughlin, president of Puget Sound Power and Light, recently issued the following statement:

"With the mounting tax burdens, there appears to be a growing feeling that public power should be taxed in the same way and to the same extent as is private power. The reason for this is that every time Government enters into competition with private enterprise, it kills off a real source of public revenue, the effect of which is to add to the taxes of those who are not tax exempt. It is realized that in one way or another, through added costs for the goods and services they buy and levies on their income, property and savings, it is the people who pay the taxes and they naturally want the burden spread around as much as possible. * * *

"Failure of Government to put itself on an equal footing with private enterprise in its proprietary activities undermines democracy, does not fundamentally enhance the public welfare and is not only unjust but harmful to those who have put their savings in private enterprise."

Where Do We Go from Here in Accident Prevention?

By H. O. Sprinkle

Chairman, Accident Prevention Committee, EEI; Monongahela West Penn Public Service Company

Address before the Annual Meeting of the Edison Electric Institute, New York, June 6, 1944

APPROXIMATELY the same things are killing and hurting our people now as were doing it 10 or 15 years ago—and they are doing it in about the same proportions. Indeed, the most discouraging thing about the whole business is the great difficulty we are having in producing any substantial changes in either the types or numbers of accidents in our industry.

Let me show you what I mean. Fig. 1 shows a 20-year record up to 1942 of three accident rates for the industry. The method of keeping statistics was changed about two years ago, and we can't give the 1943 record in exact figures, but it would show a slight decrease in number of fatalities and a slight increase in the other two curves. Please note that these are ratio scales which show percentage changes.

From a very bad experience in the early twenties a remarkable improvement was made covering a period of about 10 years. Along in 1934 we came to the end of improvement and our efforts during the past 10 years have been just sufficient to hold our own. This doesn't speak well for our industry which we all believe contains a better-than-average group of intelligent and responsible employees, nor does it speak well for the work of those in it who are interested in accident prevention. Have we reached the ultimate? Can we do no more than hold our own in the fight to reduce accidents? Must we keep on killing over 100 men a year out of a total employment of about 250,000 people? Must the industry take a loss of between 4 and 5 millions of dollars a year as the unavoidable cost of careless work and careless supervision?

I am not alone in asking these questions. I am here as a representative of the Accident Prevention Committee of this organization. You might well ask *us*. "What have *you* done about it? This is the work for which you were appointed. Your committee is made up of men who are experts in safety work, and you have been given the responsibility for this job." You might very well ask us this, and we have asked ourselves these questions. We set out about two years ago to try to find the answers. We instituted three specific lines of inquiry:

1. What types of accidents are occurring in our industry and in what proportion? Have these changed materially in the last few years so as to require a change in attack?
2. What is the status of our total effort at the present time and what is holding us back from further progress?
3. Where do we go from here in accident prevention in our industry?

We felt that if we could develop the answers to these questions we would at least have plans for a real attack on accidents. Then if we failed to make progress it could only be blamed on our failure to sell those plans or make them effective.

As an answer to question number one, I have two charts which tell part of the

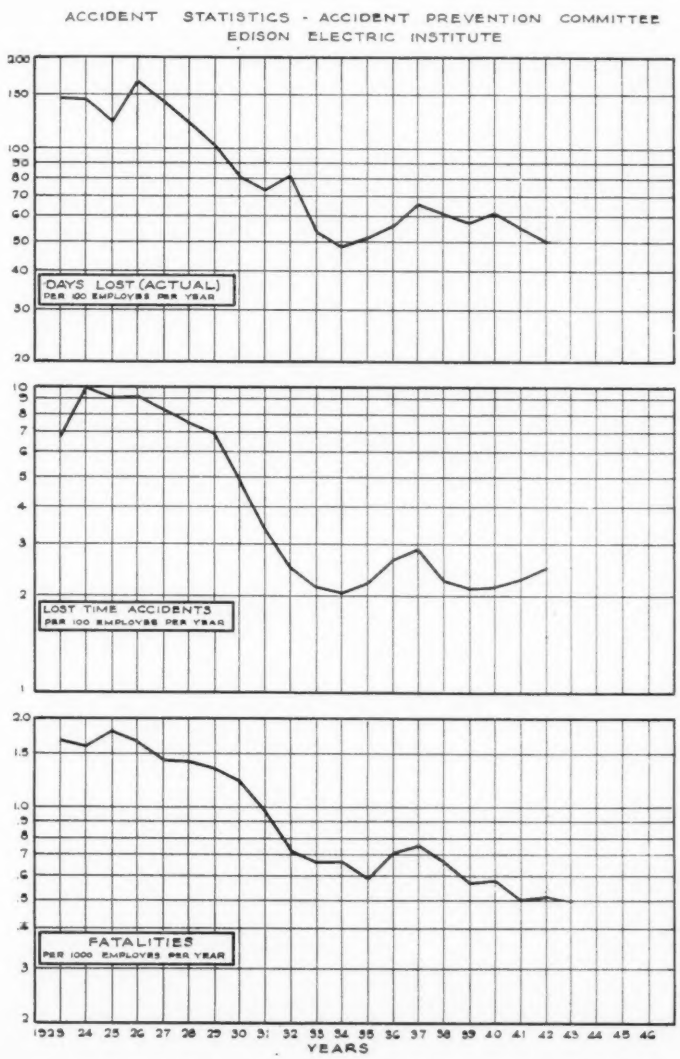


Fig. 1

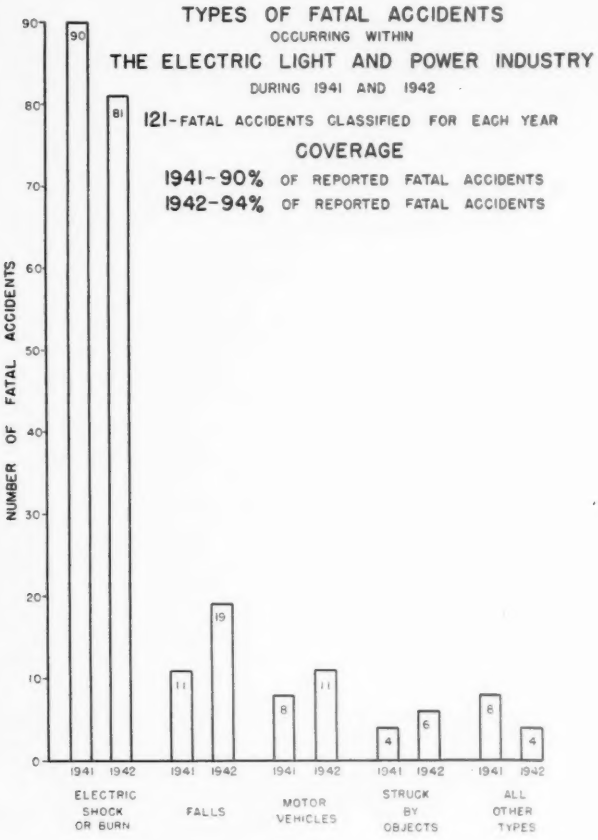


Fig. 2

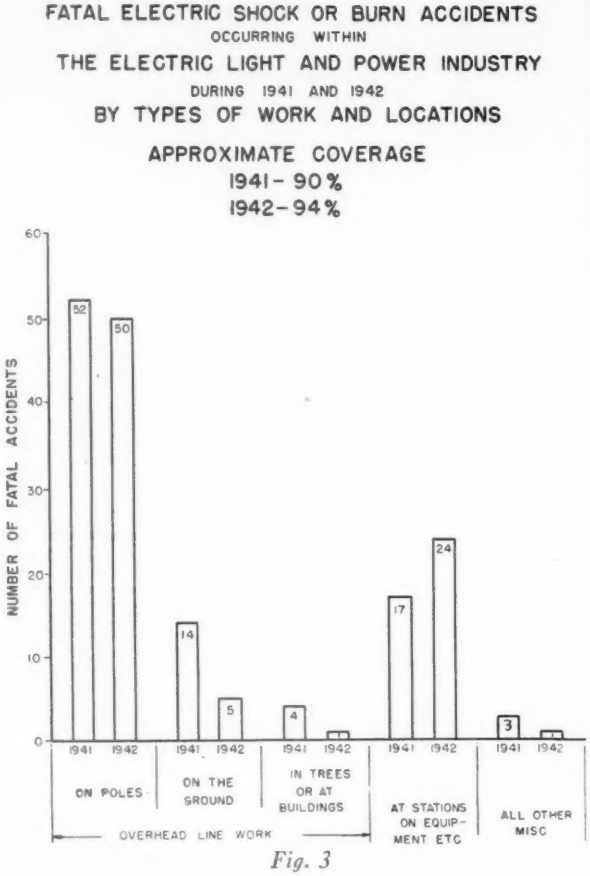


Fig. 3

story better than words. The first, Fig. 2, shows the types of fatal accidents which occurred in 1941 and 1942. Electric shock or burn fatalities amount to approximately 70 per cent of the total. A check of the last 20 years' records show about this same proportion. We just haven't made any progress industry-wide, in reducing the hazard presented by our product—electricity. There was a small decrease in shock or burn fatalities in 1942 over 1941, but the deaths due to falls increased. Analysis of our more serious lost time accidents show that falls are much more numerous as a cause than any other type. This chart shows that when we *do* have an electric contact or burn it is much more severe than ordinary accidents.

The second chart, Fig. 3, shows the location of general classes of fatal accidents in the industry. Note that pole work is far and away the most hazardous work we have. This has been the same ever since the industry started. Furthermore, our study of past records indicates that the percentages of various types of accidents haven't changed much in the last 10 or 15 years.

These two charts show that if we are to improve our accident record to any substantial degree we must learn how to avoid electric contacts, and we must develop safer work methods on poles. Sounds simple, doesn't it? And yet we haven't made any progress to speak of in the last 10 years, at least on an industry-wide basis.

Our studies of accidents indicate that we now know which kinds are most prevalent, which kinds are most serious, and we know where they are occurring. We know a great deal about the causes of these accidents. Mr. D. C. Stewart's analyses of fatal and lost time accidents has been published in the EEI BULLETIN within the past year, and gives this data in condensed and interesting form. In other words, we *know* what is happening, and it hasn't changed to any degree for the past 15 years.

Now we will give you the results of our second inquiry, namely: "What is our Present Status, and what is holding us back?" If our committee can be said to represent the industry in accident prevention work, then here is what might be called a summary of our findings. This summary will differ a little from the one previously given to the Operating Committee, because further thinking has produced slightly different emphasis.

1. An increasingly smaller gain in safety will be derived from improved plant and structure design, and from improvements in tools and equipment.

When we say an increasingly smaller gain in safety will be derived from improvements in plant structures, tools and equipment we don't want you to get the idea that we consider that no improvements are possible. There is still room for a lot of constructive work along these lines, but our study of the accidents of the last few years indicates quite strongly our major accidents are not caused by the failure of tools or equipment or by hazardous design. Our bad record is built up of neglect and carelessness in doing the average run-of-mine job where the habits of safe workmanship have not been sufficiently inculcated.

2. The future major gains in accident prevention will come from increased emphasis on job training, personnel selection, and putting responsibility for each accident where it belongs.

Here we are stressing the importance of job training, personnel selection

and placing responsibility for each accident where it belongs. You will note that these items deal almost exclusively with the personnel element. The same accident studies which justified the previous conclusion have indicated quite strongly that the element of personal attention to the work in hand and the development of safe working methods are vitally important in reducing accidents. Training must be given on every job done, and the motto of every supervisor should be "Never let a poor job get by."

In this same item we mention the fixing of responsibilities. It is a tough job to fix responsibility for an accident, but it is a lot tougher job to develop an attitude on the part of the entire organization from the top down to accept such responsibility when it is fixed and to do something about it. We can't emphasize too strongly the importance of fixing responsibility for each accident, particularly the more serious ones.

3. Safety rules exist in practically all companies, but they are not properly enforced.

In practically every case we find that the company had safety rules and instructions which would have prevented the accident had they been followed, but the supervisors had not insisted that these instructions or rules be carried out. This seems a simple thing to correct, but we must remember that in many instances the reason for not rigidly enforcing safety rules is because there had not been sufficient thought given to the selection of the safety rules. In other words, don't make a specific rule unless you intend to enforce it. After making it, however, be sure it is enforced.

4. Top management is not sufficiently effective in expressing its interest in accident prevention.

Here we stress the responsibility of management in accident prevention work. Note the phrasing—"top management is not sufficiently effective in expressing its interest in accident prevention." We fully recognize that all management is interested, but this interest must be made more effective. The power of management is that the organization will produce the results insisted upon to a greater or lesser degree. There is no substitute for an aggressive and *continuing* interest on the part of the top management of any organization. I will come back to this part a little later, as the principal purpose of my being here is to suggest to top management what it can do to help in preventing accidents.

Now let's go back to the third of our original committee inquiries, which was, "Where do we go from here?"

Perhaps we have worded this a little too pointedly because we can't tell where we are going, nor how far. We can advise in what direction we should go and what our probable final destination might be if pursued vigorously enough.

In the first place we know positively and definitely that we have not reached the ultimate low in our accident rates. We know this because there are too many companies which have gone right along improving their accident experience until there are now quite a number with rates that are more than two-thirds better than the industry average. These are not exceptional companies, they include both big and little companies. They include congested metropolitan areas and scattered areas. They do not have any different sort of employees from the rest of the industry. Must we admit that they have better managements, better supervisors, better safety departments? I don't know just how to define the word "better," but I must say these progressive companies are able to make their efforts more effective. Why can't the entire industry make substantial gains like these fortunate organizations? Certainly they would not lose in efficiency by preventing accidents.

There can be only one answer and that is: These progressive companies want to do the job enough to really work at it, while the rest of the industry merely want to do it. Would you agree with that statement? Maybe the less progressive companies don't think it is important enough to put a little extra effort into the job. It seems to us that the killing of 100 men per year, the permanently injuring of 160 others, and the loss of between 4 millions and 5 millions of dollars should be important enough to warrant a little more effort. The sad part is that it only takes a little effort. Most companies are in the position now of having their safety work to the point where just a little more emphasis, just a little more coordinated attack on the problem, just a little more attention would put the job over. It isn't as though we had to make an about-face and start out on some brand new course. The course is charted. We know what is causing our accidents and the successful companies have shown how to avoid them. Why don't more of us do it? *You* will have to answer that one, because some of these are your companies. Why don't you check your own outfit and see how you stand, if you aren't satisfied, get your head men together and find out why.

Gentlemen, we in the Accident Prevention Committee aren't trying to pass the buck to management, but we do need help. Our study has shown that in every case where the management has insisted upon results, those results were obtained. That is the power of management for which there is no substitute. Nothing can take the place of it. The subordinate organization will always accomplish to a greater or lesser degree the expressed purposes as set forth by management, but that expression must be continuous. Do you recall that I previously stressed the continuity of effort? You are all very busy men with a multitude of demands upon your time. It is up to you to budget your time for those items which you think require your personal attention. We feel absolutely sure that all of you are in favor of improving yours and the industry's accident experience. We wonder if you realize how little of your time it would take to really make your interest effective.

I hope you won't get the idea that we are saying future progress in this work depends solely on your efforts. You will recall, however, in the 4 point summary I gave you a few minutes ago, the second item stated that future gains in accident prevention will come from increased emphasis on job training, personnel selection and placing responsibility for each accident where it belongs. It is obvious that these items involve company policies, departmental authority and responsibilities, and many other allied factors where the safety director cannot function independently. The safety director can advise what should be done, but only management has the authority to make that advice effective. In all the companies where real progress has been made it has been the result of intelligent planning *plus* the energetic and continuous support given by management. For instance, suppose the fixing of responsibility for an accident involved the failure of a department head to enforce some safety rule, or that he permitted an obviously incompetent supervisor to direct the work of a group of men. It takes real cooperation between the safety director and the management of that company to put over the lesson that can be learned so that *all* department heads will learn where they fit into the picture. The safety director cannot do it alone, regardless of how good a man he is, and

(*Continued on page* 272)

Coming—1944 SUPPLEMENTS TO THE

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These New Sections of the Manual are trimmed and punched to fit the binder accompanying the first series of sections published in 1941. (A few sets of the 1941 sections are still available.)

The three Sections of the 1944 Supplement listed above are priced at

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Taxes of Publicly-Owned Plants Are Only 3% of Revenues

THE Federal Power Commission has recently published a pamphlet, giving the statistics of 96 Class A and B publicly owned electric utilties for the year 1942. These include the TVA; various reclamation, irrigation and "public utility districts," as well as municipal plants. Of these utilities, 94 reported income statements which, when added together, give the following totals:

	Gross Reserves	*Total Taxes**	*% Revenues*
88 Publicly Owned Utilities	$117,428,351	$2,051,330	1.75
TVA & 5 Tennessee Cities	43,962,355	3,112,424	7.08
Total Class A & B Reporting	$161,390,706	$5,163,754	3.2%

* Taxes or "tax equivalents paid to municipality."

Of the 94 reporting public power systems, 42 reported no taxes or "tax equivalents" whatever and 7 more reported taxes of less than $1,000.

In comparison, total taxes paid by privately owned electric utilities were $628,000,000, or 24.1% of gross revenues of $2,609,000,000.

Grounding of Electric Circuits on Water Pipes

EARLY this year the American Research Committee on Grounding issued an Interim Report of Investigations, a summary of which appeared in the March issue of the BULLETIN. In the complete report, under the heading of "Laboratory Investigations" it was mentioned that laboratory tests on sections of pipe carrying water were being conducted by the American Water Works Association and New York University in an attempt to determine whether current on the pipe affected the metal concentrations in the water delivered from the pipes.

Following the completion of this investigation a report appeared in the May, 1944, issue of the Journal of the American Water Works Association, indicating that under the conditions tested neither alternating current nor direct current flowing on the pipes had any appreciable effect on the quality of the water in the pipes. This report, together with the Interim Report and a statement of the American Water Works Association policy was reprinted under the title of "Grounding of Electric Circuits on Water Pipes," and is available at a price of 25c per copy from the American Water Works Association, 500 Fifth Avenue, New York 18, N. Y.

Of Interest to Canadian Utilities

CONSIDERATION is now being given to a general revision of the Canadian Electrical Code, Part I, preparatory to the publishing of a Fifth Edition. Sub-committees have been organized to review the various Sections of the Code and are now actively engaged in the work of revision.

Any and all proposals for revision will be welcome and should be submitted without delay to the Canadian Standards Association, Research Bldg., Ottawa, in order that fullest consideration may be given. All such proposals should, if possible, be in the form of the actual text desired for incorporation as new or revised Rules in the Fifth Edition of the Code.

The closing date for receipt of proposals for revision is October 1, 1944. Requests for revision, received after that date, may be held for consideration in the next subsequent general revision.

Annual Meeting, Canadian Electrical Association

THE 54th Annual Meeting of the Canadian Electrical Association was held at Murray Bay, Quebec, on June 22 and 23, at which over 350 delegates were in attendance.

President Alan Brown, in his address referred to the last meeting held at Murray Bay in 1936 and outlined the tremendous advances made by the industry in the intervening period. "In 1936," he stated "Canadian utilities, privately and publicly owned had an installed capacity of 7,945,590 hp and generated 23,829,067,000 kwhr of electrical energy. In 1939 they had an installed capacity of 8,289,212 hp and generated 26,429,940,000 kwhr of electrical power, and in 1943 the total installed capacity reached 10,940,513 hp which generated a total of 40,377,649,000 kwhr of electrical energy.

"From 1936 to 1939 the installed capacity increased by 4.4 per cent and energy produced by 11 per cent.

"In four years of war the installed capacity increased by 24.8 per cent and the energy produced by 52½ per cent, and during these war years there has never been a shortage of power for the production of war matrials, nor has there been any work stoppage by employees of the electrical utility industry."

Mr. Brown referred to the appointment of a Commission in the Province of Quebec which took over the property of Montreal Light, Heat & Power Consolidated on April 15 last, for which no payments or offer of payments has been made to the company or the shareholders as yet and some time may elapse before the expropriation is concluded.

Reference was made to taxation of privately-operated utilities and in this respect Mr. Brown stated "the money received by private corporations is being turned over to the Federal Government (through income and excess profits taxes) to fight this war, while that received by publicly-owned corporations is being set aside in the form of reserves to such an extent that their operation cannot help but appear in a favourable light . . . unless some relief is forthcoming in the near future, private enterprise will not be in a financial position to make its proper contribution to relieve post-war unemployment. . . . the taxes paid by Canadian industry have increased by 287 per cent from 1939 to 1943 and in spite of the increased production and sales, profits were down 12 per cent during the same period."

He foresaw a bright future for the manufacturer of electrical appliances and equipment but stressed the need for a reasonable part of the export market. The utility industry in Eastern Canada will likely have a surplus of power immediately following the war, particularly in the Province of Quebec. New industries and new uses for electricity will have to be found to absorb this surplus and he called for post-war planning now to develop new markets and attract new industries, so long as such planning does not take from the war effort.

Referring to rural electrification, Mr. Brown felt that a utility company has a certain obligation to serve the area in which it operates and should be prepared to extend its lines and services so long as it is able to maintain a sound financial position.

He called for better public relations and a clarification of utility financial statements to acquaint the public with the fact that utility earnings are but a few cents on each dollar of investment.

B. C. Fairchild, managing director of the Association, reviewed the activities of the various Association Committees during the past year and referred to the Annual Winter Conference held in Montreal in January and the Western Conference held in Calgary in March.

The post-war planning activities of the Association, under the chairmanship of W. C. Mainwaring, B. C. Electric Railway Co., have been merged with those of several other organizations under an overall body known as the "National Industrial Federation," which will continue and expand the development of post-war plans to include all industries, based on the plans of the Committee for Economic Development (CED).

Progress is reported in an Employee Training Program for the rehabilitation of returned men and training of new employees which is being planned with the Department of Pensions and National Health.

Members in the Association totaled 768 as of June 15.

Speakers included Dr. G. M. Weir, Acting Director of Training, Dept. of Pensions and National Health, Ottawa, who spoke on "Jobs for the Fit and Fitting the Unfit for Jobs," in which he dealt with the rehabilitation problem and outlined what the Government is doing to solve it. He called on industry to collaborate with rehabilitation officers in at least three phases of training:

(a) Selection and sponsorship of trainees for the specific industry concerned;

(b) Curricula and Instruction—in order that the training may be more closely related to the practical needs of the industry in question and of similar industries;

(c) Placement of trainees and their subsequent supervision or retraining.

E. V. Sayles, General Engineering Supervisor, Consumers Power Co., Jackson, Mich., and past chairman of the EEI Transmission and Distribution Committee, spoke on "Problems ahead for Electric Utilities which offer the Greatest Possible Opportunities for Further Study." "The engineer," said Mr. Sayles, "must be so intimately acquainted and closely associated with the operation of the generation, transmission and distribution portions of the system that he has a keen sense of balance between the two somewhat divergent desires of low plant investment and expense of operation."

Suggestions are made relative to the method of serving far greater load in the future and are intended to indicate ideas worthy of future study.

Three principal classes of problems will have to be studied, i.e.:

(1) Power requirements of individual industrial customers where manufacturing changes require immediate attention.

(2) Deferred maintenance and construction resulting from scarcity of labor and materials.

(3) Long range studies based on estimates of future load growth influenced by such factors as then seem proper.

J. T. Crowder, secretary-manager, National Industrial Federation, Toronto, spoke on the development of the CED plan for Canadian industries' post-war program and called on member companies for their support in this important undertaking.

Various Committee reports were presented and discussed at concurrent meetings of the Utilization and Sales and Engineering Sections.

Officers elected for the coming year are as follows: President, J. B. Hayes; Vice-Presidents, J. K. Wilson, E. V. Caton and H. E. Pawson; Treasurer, W. Booth; Managing Director, B. C. Fairchild.

The Executive Committee consists of Messrs. W. D. Bracken, A. C. Brittain, J. J. Doolan, E. D. Gray-Donald, B. M. Hill, T. Ingledow, Geo. Kirlin, F. Krug, F. L. Lawton, G. D. Leacock, I. M. MacLean, I. A. Mahon, E. C. McGovern, W. H. Munro, J. N. Sicard, F. Walker, W. R. Way and F. T. Wyman.

PERSONALS

A. C. BLINN, president of Ohio Edison Company, has been elevated to the chairmanship of the board and WALTER H. SAMMIS, who became a vice-president of Ohio Edison Company in 1933, was elected president to succeed Mr. Blinn.

President of the Company since 1938, Mr. Blinn has been identified with Ohio Edison and its predecessors since 1916, at which time he went to Akron as vice-president and general manager of the Northern Ohio Traction and Light Company. He brought about the enlargement of that utility and was active in the consolidation in 1930 of the Ohio company with the Pennsylvania-Ohio Power and Light Company, another utility, into the Ohio Edison Company, being made vice-president and general manager of the new company.

Mr. Sammis, the new president, is a native of the Village of Hempstead, Long Island and is 48 years of age. He graduated from Columbia University in electrical engineering in 1917, and served in World War I as machinist in the navy and later as ensign. His first employment in the utility industry began as an electrician's helper with the Brooklyn Rapid Transit Company. Then he became a switchboard operator in a steam electric plant of the Public Service Electric and Gas Company in Jersey City, N. J. In 1920 he joined the engineering staff of Consumers Power at Jackson, Mich., and in 1922 was made power sales engineer for that company. He was employed by C. H. Tenney & Company of Boston in 1925 on power sales and rate analysis work for various electric utilities. He rejoined Consumers Power in 1926 and three years later went to New York with a predecessor of The Commonwealth & Southern Corporation, holding company for Ohio Edison Company.

Beginning in 1933, he became closely associated with the operation of both Ohio Edison and Pennsylvania Power Companies as vice-president and president respectively of the two utilities.

Prior to becoming president of Ohio Edison Company, Mr. Sammis resigned as a director and vice-president of The Commonwealth & Southern Corporation (N. Y.) and as a director and vice-president of Consumers Power Company.

Mr. Sammis is well known in public utility circles and has taken an active part for many years in matters pertaining to the growth and development of the light and power industry. He is on the board of directors and also the executive committee of the Edison Electric Institute.

JOHN T. KIMBALL has been elected a vice-president and director of New York Power and Light Corporation and also a vice-president of the Central New York Power Corporation, whose headquarters are at Syracuse.

Since 1932 Mr. Kimball has been rate and valuation engineer for the companies in the Niagara Hudson System. He will continue to act as a consultant for the companies in the western division of the Niagara Hudson System.

Mr. Kimball was born in Janesville, Wis., and was graduated from the University of Wisconsin with a degree of Bachelor of Science in Electrical Engineering. From 1914 to 1915 he was a valuation engineer with the Bell Telephone System in Chicago, and for the next two years was a staff engineer with the Wisconsin Railroad Commission. From 1918 until coming with Niagara Hudson in 1932 Mr. Kimball was on the staff of Ford, Bacon & Davis, Inc., consulting engineers, in New York City.

DEAN C. OBER has been elected a vice-president of The Cleveland Electric Illuminating Company. He will be in charge of engineering and operations.

Mr. Obert began his career with the company while a student of electrical engineering at Case School of Applied Science, working for the company during his college vacations.

He was graduated from Case in 1913, and a year later went to work for the company as an electrical engineer. In 1933 he was promoted to executive engineer and later was appointed manager of operations.

Mr. Ober was born in Chagrin Falls. He now lives at 1836 Sheldon Avenue, East Cleveland, with his wife and son. He has two married daughters.

HENRY M. GALLAGHER, Waseca, former Chief Justice of the Minnesota Supreme Count, has been elected a director of the Northern States Power Company of Minnesota.

Judge Gallagher was born on a farm in Waseca County, Sept. 10, 1885. He was educated in the grade and high schools of Waseca and was graduated from the Law College of Creighton University, Omaha, Neb., with a Bachelor of Laws Degree in 1910. In 1938 he served as president of the Creighton University Alumni Association of Minnesota. He was admitted to practice before the State Bars of Minnesota and Nebraska that year and practiced law at Waseca from 1910 to 1937.

He served as Municipal Judge at Waseca 1912-1914 and was County Attorney of Waseca County 1914-1915 and again from 1918 to 1922. He served as a member of the State Board of Law Examiners from 1926 to 1931 and as a member of the Minnesota State Industrial Commission during 1931 and 1932.

He was appointed Chief Justice of the Minnesota Supreme Court in February, 1937, and was re-elected in 1938 by the greatest vote and majority in the history of the state for judicial office. He served until January, 1944, when he retired to resume private practice.

WALTER J. THOMPSON, manager of the Advertising Bureau and director of public relations for the Buffalo Niagara & Eastern Power Corporation, has been appointed vice-president of the corporation.

Mr. Thompson joined the corporation in December, 1930, as editor of its employee magazine, *The Niagara Hudson News*. Three years later he was named manager of the Advertising Bureau which he has headed since that time.

A native of Buffalo, the new vice-president was graduated from Canisius High School. He received his A. B. degree from Georgetown University and also attended Harvard Law School.

Following his graduation from college, he worked as a newspaper reporter in Washington, D. C. From 1926 to 1930 he was assistant supervisor of public relations for the International Railway Company. He was elected president of the Buffalo Junior Chamber of

Commerce for the year 1934-35, is a captain and intelligence officer of New York State Wing, Civil Air Patrol, vice-president of the Buffalo Public Relations Council, a member of the operating committee of the USO, and a member of the Buffalo Chamber of Commerce, and of the Erie County Committee for Economic Development.

J. ARTHUR APSEY, Display Supervisor of Buffalo, Niagara & Eastern Power Corporation, has been promoted to manager of the Advertising Bureau.

DONALD C. FRANK, assistant supervisor, will succeed Mr. Apsey as supervisor of exhibits and displays.

Mr. Apsey will handle the company's commercial advertising, radio and direct mail and post-war sales advertising. All public relations activities will continue under the direction of vice-president Walter J. Thompson.

The new commercial advertising manager is a native of Buffalo and received his education at old Masten Park High School and the Albright Art School. He entered the service of the company in 1929 as a window trimmer and became supervisor of window and store displays in 1935.

Mr. Frank has been in the display department of the company since 1930.

EDWARD T. AUGUSTINE has been appointed assistant chief engineer of the Western Massachusetts Electric Company. He was formerly district engineer in the western division of the Western Massachusetts Electric Company, with headquarters in Pittsfield. In his new position, he will be located in Springfield.

Mr. Augustine was born in Centralia, Columbia County, Pa. He graduated from the Thomas S. Clarkson Memorial College of Technology, Potsdam, N. Y., in 1924 with the degree of bachelor of science in electrical engineering. He received the degree of master of science in electrical engineering in 1926, and the degree of electrical engineer in 1928.

Following his graduation from college in 1924, he entered the employ of the General Electric Company as a student engineer, and spent a total of 17 months in the testing departments in the Schenectady, N. Y. and Pittsfield, Mass., plants.

From 1926 to 1929 he was employed by the Philadelphia Electric Company as an engineer in the electrical engineering department.

He joined the Western Massachusetts Companies' organization in 1929, as system planning engineer in the electrical engineering department. In 1932 he was transferred to Pittsfield as district engineer.

JAIRUS F. BURT, since 1932 promotional sales manager of the western division, Western Massachusetts Electric Company, Pittsfield, has been appointed assistant manager, following the promotion of C. S. Van Buskirk. Mr. Burt was born in Easthampton, Mass., and after serving in the U. S. Navy in World I was in the General Electric laboratory for a year, after which he took a two-year course at Pratt Institute, Brooklyn, N. Y., in industrial engineering. He returned to General Electric and served at Bloomfield, N. J., Schenectady and Pittsfield. In 1924 he joined the Pittsfield utility as a lighting specialist, and in 1928 was made sales manager in charge of electrical merchandise. In 1931 he was transferred to Springfield, Mass., as assistant to the general sales manager of the Springfield section of the Western Massachusetts group, returning to Pittsfield in his recent position in 1932.

L. V. SUTTON, president of the Carolina Power & Light Company was awarded the honorary degree of doctor of engineering by North Carolina State College at the recent commencement exercises.

L. W. NIMS, military liaison officer for the Utah Power & Light Company since 1940, recently was appointed director of personnel for that concern following the resignation of DR. ADAM S. BENNION, who had carried the duties as assistant to the president. As military liaison officer, Mr. Nims, has aided war establishments in making use of electrical facilities and has directed the protection of the company's properties against subversive activities. A veteran Utah Power employee, Mr. Nims has served as power plant operator, division superintendent, traveling maintenance engineer, system power dispatcher and as division manager at Ogden and Provo, Utah, and Rexburg, Idaho. Before joining Utah Power, he served four years in Mexico on construction work for the Mexican Light & Power Company.

J. L. SHORES has been named safety engineer of the Alabama Power Company to succeed Joe Speed, resigned. Mr. Shores has been in the safety department of the company since 1925 and since 1938 has been safety engineer for the eastern and western divisions, Gorgas and Gadsden steam plants, and Lay and Mitchell dams.

ALFRED M. WADE, manager of the Rockville-Stafford district of the Connecticut Light & Power Company since December, 1941, has succeeded the late Frederick J. Lyon as manager of the Greenwich district. Mr. Wade is a graduate of Union College, Schenectady, N. Y., and joined the company in 1924 in the advertising department. In 1928 he resigned to enter the service of the General Motors organization, and later spent three years as assistant sales manager in India. He returned to the Connecticut utility in 1932, joining the sales department, and nine years later went to Rockville. Donald R. Weekes, Greenwich office manager, has become manager at Rockville, and has been succeeded at Greenwich by J. George Westerman, former traveling auditor of the company. Mr. Weekes joined the company in 1928 and was appointed to his late post in Greenwich in 1934. Mr. Westerman entered the company's service in 1929 and has been on the traveling auditing staff since 1936.

HENRY C. CHAPIN, former district engineer at Greenwich, has been appointed electric foreman for the southern division, having charge of all substation operation and maintenance in Greenwich, Norwalk and five other municipalities. Daniel Forger, who entered the company in 1922 as a meterman, and who has since worked on electric distribution layouts, maintenance and construction as assistant engineer, becomes district engineer at Greenwich.

Higher Distribution Voltages for Post-War Loads

(*Continued from page* 252)

at least sacrifice nothing of safety to workmen and to the public. Lines can be worked alive with little, if any, added cost, and with probably greater safety than prevailing 4-kv lines worked with rubber gloves and guards. Tree clearance in the overall is not a more extensive problem.

(5) Simplified construction, encouraged by the fewer wires, especially in residential areas where single-phase laterals predominate, lends much to improved appearance.

(6) That these conclusions are well founded is borne out by a steadily enlarging background of experience of many companies.

The Heat Pump

(*Continued from page* 247)

home. On the contrary, it is all set to make every home it can reach less electrical than it is today. We should have no quarrel with them for that attitude. But those in the electric industry who have no gas responsibilities are particularly concerned with expanding electric use. It is this group, therefore, that must make up in enthusiasm and intensity of effort for the failure of the electric industry to do more than it has done to date with the heat pump idea. They have to make up for a lot of time lost in the last decade in the course of which the competition to electric heating of homes has made large forward strides. But it may not be too late.

All the above I believe are sound suggestions and should be adopted by every utility interested in protecting its domestic market and in the expansion of electric use on a scale heretofore and, without it even now, almost inconceivable.

The all-electric home? Certainly. It can be brought about and made as real as electric lighting in almost every American home. But in the vast majority of cases it will not earn the right to be called all-electric until it is heated electrically. The heat pump appears to be the only practical means known today or discernible on the horizon for bringing this about. Let us initiate some earnest efforts to make it a reality.

Discussion of Mr. Monteith's Address

(*Continued from page* 261)

same time we go a long distance toward meeting competition from public power.

I want to add a further word about making capital improvements to save operating labor—the introduction of labor saving devices if you wish. It may sound like fakery to talk about that now when we know we will have a legal and moral obligation perhaps within the next year to take back our employees who are now in military service, but the matter is really one of timing. In the long run we know that better standards of living and our whole economic salvation is dependent on improved labor efficiency. We know that the total number of employees in the electric industry will not decline because the best we can achieve in improving the efficiency of labor by mechanical means will be more than offset by our growth in load. To the extent then that we are able to use a surplus of labor now or soon when we must employ it in the interest of our future welfare, for the purpose of constructing facilities that will provide future savings of labor and other operating economies, to that extent we are adding to the future ultimate welfare.

In such a short discussion one can only hint at the economic implications of Mr. Monteith's paper. I have tried, however, to stimulate the growing consciousness that we must do something about our operating costs and that this endeavor must have a place in our defense against the encroachment of public power. I think we will be well advised to accept and encourage all the help we can get from the manufacturers in this effort.

Where Do We Go?

(*Continued from page* 267)

regardless of the fact that at one time the management of his company might have told him he would be supported in his efforts. It takes continuous support.

Let me repeat the plea I made to the Operating Committee last November. Would you be willing to give one hour per month, every month in the year, to accident prevention? That seems little enough for planned attention. Of course you might have to attend some safety functions and things of that sort on the side, but for a continuous part of your working program, a one hour minimum budget can do wonders. Here are some suggestions as to how that hour should be spent to produce results. You may think of other ways, and for your men's sake don't limit yourself to one hour unless you are badly pushed for time.

First, cal' in your safety director, your personnel director and your executive staff. Lay the reports in front of them and ask them how you stand with relation to the industry record. Ask them what they are doing to prevent accidents. They will give you a nice set of answers (we all know the correct answers), but keep on digging a little to let them know you don't want "pat" answers, but facts. Every company, of course, has safety rules, and of course every company is sold on accident prevention. Apparently that *doesn't stop* accidents. You really have to enforce your safety rules, and you really have to sell every one that an efficient job is a safe job, and you have to fix responsibilities for an accident when it happens. If you will just take a few minutes to make it known that you are damned well interested in the matter, you will have done something for which there is no substitute. Your outfit will know you want results.

And now comes the second step, which, if possible, is more important than the first. Once each month thereafter call together the same group as above and ask for a progress report. As a part of your hour's job, take an accident, ask the safety director to analyze it, and fix the responsibilities. Just do that once a month and watch your accident record improve.

I cannot presume to say what the ultimate goal might be in preventing accidents. Our committee feels that a 50% reduction in our present rates is entirely feasible. Many companies have done much better than that, but we can't hope for the entire industry to be that good. If we can make a 50% reduction we will save every year approximately 50 men's lives and about 2 millions of dollars plus countless hours of suffering. It seems to us that this goal is worthy of effort to achieve. Your undoubted interest and support is tremendously valuable and appreciated, but if all our present effort is only sufficient to hold our records level, then we have to do more than we are now doing. Those of you whose records are not now better than the industry average have a right to demand "why"? And if you are looking for some way to help, try my suggestion above unless you can think of a better one. The main idea is, let's get off dead center and get going somewhere. Maybe it will be in the direction of greater safety.

CONVENTIONS AND MEETINGS

SEPTEMBER

12-13	Accident Prevention Committee, EEI Headquarters, New York, N. Y.
14-16	Illuminating Engineering Society, Edgewater Beach Hotel, Chicago, Ill.
20-22	Indiana Electric Association, French Lick Springs Hotel, French Lick Springs, Ind.
21	American Standards Association, Standards Council, New York, N. Y.

OCTOBER

2-3	Prime Movers Committee, EEI, William Penn Hotel, Pittsburgh, Pa.
3-5	National Safety Congress of National Safety Council, Chicago, Ill.
5-6	Electrical Equipment Committee, EEI, Schenley Hotel, Pittsburgh, Pa.
9-10	Transmission and Distribution Committee, EEI, Hotel Statler, Buffalo, N. Y.
12-14	Southeastern Electric Exchange, Sales Conference, Atlanta, Ga.
23-27	National Electrical Manufacturers Association, Waldorf-Astoria Hotel, New York, N. Y.

NOVEMBER

27-30	American Society of Mechanical Engineers, New York, N. Y.

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